(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL, Business Manager.

F. H. THOMPSON, Eastern Representative

R. V. WRIGHT, E. A. AVERILL, } Editors.

JUNE, 1909

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THE MOTIVE POWER MAN AS A SUCCESSFUL OPERATING OFFICIAL.

The motive power officials have been responsible to a certain extent for the condition which has led to placing them, in the past, in a subordinate position in the official list of operating officials, because of the fact that in the study of operation they have clearly taken a backward step by advocating a low tonnage for the purpose of saving the locomotives as much as possible. Of late there has been a radical change in this position and we now find practically all the superintendents of motive power advocating as high tonnage per train as possible, knowing full well that the expense per thousand ton miles of maintaining locomotives, and all other operating expenses are reduced directly with the increase of train load. There is no danger whatever of overloading locomotives at the present time, since the tonnage must be regulated by the time that each train is required to make.

The operating efficiency of a road depends very largely upon the class and condition of power and the motive power department, when given all the money necessary to keep the power in first-class condition, can aid wonderfully in the operating efficiency by doing everything possible to increase the loading of trains to a point where the tonnage will not be either above or below the amount necessary to maintain the required schedule.

The motive power officials or those who have had experience in the motive power department, have done practically all of the work in connection with the question of train resistance and tonnage rating, and the result of their work is demonstrated in the decrease of operating expenses when they are working in thorough harmony with the other operating officials.

The mechanical officer is an operating as well as a mechanical official, as is shown by the fact that a large number of them have been recognized in the last few years and promoted to higher positions in the operating departments of the railroads. In each of these cases their rise in the service can be attributed to the fact that they had the capacity for grasping the operating problems as a whole and not from a mechanical standpoint only.

SUPERHEATED STEAM.

Having decided that superheated steam is a good thing in locomotive practice, and it seems to be pretty generally admitted that it is, at least as far as the economy in the engine part of the locomotive is concerned, the next question for decision is the proper degree of superheat to use. There is a wide range of temperature of steam above saturation, which can be obtained on a locomotive and there are strong advocates for the use of both ends of the scale. Some very capable engineers are arguing in favor of a superheat in the neighborhood of 50 degs. above saturation temperature and others advocate from 125 degrees up. The article by Mr. Cole in this issue discusses the whole question in a rational manner and concludes that the greatest economy will be obtained at the higher degrees of superheat. The same conclusion is voiced by Robert Garbe in his articles on "The Application of Highly Superheated Steam to Locomotives," which are based on probably the most extensive experience with locomotive superheaters of any engineer. He states that an average temperature of 570 degs. F. must be maintained in the valve chamber and that the coal and water consumption are considerably increased whenever the temperature falls any appreciable extent below that figure. The tests reported in his articles all average well over 600 degs. temperature in the steam chest, in one case the temperature for a short time being over 700 degs. These were on locomotives carrying 170 lbs. of steam and thus gave a superheat of from 225 to 332 degs.

Steam as used in steam engine practice is simply and entirely a vehicle for transferring heat from the firebox to the cylinder, where the heat is utilized and the vehicle discarded, or in the case of condensing engines, sent back to be used over again. Its work is analogous to that of any other vehicle, as for instance a freight car. The operating and traffic departments of our railways devote a large amount of time and energy in obtaining high average loads per car mile on their lines, it being perfectly evident that an average lading of 30 tons per car is much more profitable in every way than 20 tons per car. A car has to be hauled even if it contains but 5 tons and it will cost but little more to haul it with 30 tons lading. The same thing applies to steam. We have a vehicle which must go over the route and as we want the heat at the other end of the line, why is it not advisable to load each cubic foot of steam with all of the heat that can be used at its destination—the cylinder. In other words, instead of using three 50-ton cars to carry 100 tons of coal, why not put it all on two, provided, of course, that 100 tons can be used at the end of the line. Of course, there are many things in connection with superheated steam which have no analogy in freight car lading, but on the other hand there are features which make them very similar.

TEST OF LOCOMOTIVES WITH SUPERHEATER AND FEED WATER HEATER.

In 1907 the Central of Georgia Railway received from the Baldwin Locomotive Works an order of ten consolidation locomotives, seven of which were simple engines with Stephenson valve gear. Of the remaining, one was the same design of locomotive fitted with the Walschaert valve gear and numbered 1222; another, No. 1223, had the Walschaert valve gear and was fitted with an original design of feed water heater, which uses a duplex pump in place of an injector. (This locomotive and heater was fully described on page 71 of the February, 1908, issue of this journal.) The third locomotive, No. 1224, was of the same type, but had a Baldwin superheater, the steam pressure being reduced from 200 lbs. to 160 lbs. and the cylinders enlarged from 20 to 22 in. in diameter.

In January of this year it was decided to make an accurate practical comparison of these three different arrangements of locomotives and a train consisting of 15 cars loaded with coal was handled each way over the division from Macon to Columbus, a distance of about 100 miles, by each engine in turn, the test also including the data on locomotive No. 1081, which is of the same class, but had Stephenson valve gear. The locomotives were operated by the same engineer and fireman in each test, the tests being run on consecutive days. The train was identical in each case and the coal and water was, of course, of the same quality The tests were made primarily to find out the difference in coal and water consumption and these were very carefully weighed and measured.

The results shown in the accompanying table are very decidedly in favor of the locomotive with the feed water heater, which

LOCOMOTIVE NO.	1224	1223	1222	1081
With	Baldwin Superheater	Feed Water Heater	Walschaert Valve Gear	Stephensen Valve Gear
Steam pressure, lbs.	160	200	200	200
Cylinders, in.	22 x 28	20 x 28	20 x 28	20 and 28
Drivers, in.	57	57	57	57
Heating Surface, Sq. Ft.	2458	2314.3	2314.3	2263.8
Grate Area, Sq. Ft.	44	44	44	44
Tractive Effort	34000	34000	34000	34000
TRAIN NOS.	35 and 38	35 and 38	35 and 38	35 and 38
Date, Jan. 1909	4 and 5	6 and 7	8 and 9	11 and 12
Time on Road, Round Trip	13 h-29 m	13 h-51m	13 h-35m	13 h-37 m
Stops, Number	19	18	23	17
Stops, Time Consumed	2 h-29 m	2 h-23 m	2 h-40 m	1 h-46 m
Ton Mileage, Total	205740	205740	205740	205740
Coal Consumed, lbs. total	24200	20050	23700	22650
Coal Consumed, per 1000 T.M	118	98	115	110
Water used, lbs. total	168866	144375	166100	156242
Water used, per lb., Coal	6.98	7.13	7.01	6.90
Miles run, per ton of coal	16.5	19.8	16.9	17.7

burned but 98 lbs. of coal per 1,000 ton-miles as compared with 110 for the simple locomotive with Stephenson valve gear and 118 for the superheating locomotive; it evaporated 7.13 lbs. of water per lb. of coal as compared with 6.98 for the superheater locomotive.

SELF CLEARING ASH PANS.

On and after the 1st day of January, 1910, it shall be unlawful for any common carrier engaged in interstate or foreign commerce by railroads to use any locomotive, in moving interstate or foreign traffic, not equipped with an ash pan which can be dumped or emptied and cleaned without the necessity of any employee getting under such locomotive.—Approved May 30, 1908.

The so-called ash pan law, the first section of which is given above, applies to all railways handling interstate traffic in any of the States or Territories of the United States and the District of Columbia. Its enforcement is intrusted to the Interstate Commerce Commission, whose powers are extended for that purpose and a penalty of $200 for each and every violation of the law is provided.

This law requires the application to all locomotives of a design of ash pan which does not require the use of a hoe or bar for cleaning unless these tools can be used by men standing alongside the locomotive. Practically all the wide firebox engines, both hard and soft coal burning, are already properly equipped, as are also a fair proportion of the narrow firebox type where the firebox rests on the frames. Practically none of the locomotives with narrow fireboxes set between the frames have had ash pans which are self-clearing, and it is for pans on this type that the chief difficulty has been found in changing the equipment to comply with this law.

The problem is affected, on all classes of locomotives by the climate, as men will not be allowed to go under the engine to break loose the doors or contents of a frozen ash pan. This applies to the self-clearing hopper design as well as to the flat, shallow pan. This feature has been considered in some of the hopper designs shown herewith, and heating pipes near the slides have been provided, these, however, being intended more for loosening a frozen door than to thaw the contents, which will probably have to be loosened up by pounding on the outside of the hopper. In some of the designs of shallow pans illustrated, heater pipes for loosening the whole contents of a frozen pan have been provided.

With wide firebox locomotives the ash pans are usually of the hopper type which, if the opening is at the bottom, makes them self-clearing in the ordinary accepted sense of the term and the difference of design on these locomotives consists principally in the kind of a door used to close the hopper opening.

The principal requirements of a satisfactory ash pan door are that it be capable of being closed sufficiently tight to prevent hot cinders escaping and that it either will not warp or at least be capable of being properly operated when somewhat warped and at the same time form a comparatively tight joint with its frame.

There are, in general, three designs of ash pan doors on hopper pans in use. First, and by far the most common, is a sliding door, which usually slides longitudinally in a guide on the bottom of the hopper. The second method is to use an ordinary hinged door, which is closed and held in place by connecting rods from an arm on the operating shaft. In a few cases only is this type of door automatically locked when closed. The third method is what might be termed a swinging door, *i. e.*, a door hung from links pivoted above and ahead of the center line of the hopper which allow the door to swing downward and forward to entirely clear the opening. In addition to these, there are several special arrangements which will be illustrated and described later in this article.

With the shallow type of ash pans applied to narrow firebox locomotives, more particularly those with the firebox between the frames, there are two principal methods of making them self-clearing, or at least practically so. The first, and apparently the most popular way of doing this, is the installation of steam or water nozzles, or jets which will blow the contents of the pan through the opening at the end. This arrangement is sometimes in the shape of several nozzles in the front of the pan only and, in at least one other case, consists of cross pipes distributed along the bottom of the pan and having small openings arranged to give jets which will force the contents toward the rear. The other method used on shallow pans is to provide openings in the bottom, usually closed by means of sliding doors. This scheme does not always give an absolutely self-clearing pan, but approaches it very closely. Several arrangements of the jet scheme will be illustrated and described later.

Considering in detail some of the designs which fulfil the requirements of the ash pan law and have been in successful use for some time, following the general scheme of classification given above, we will first take up

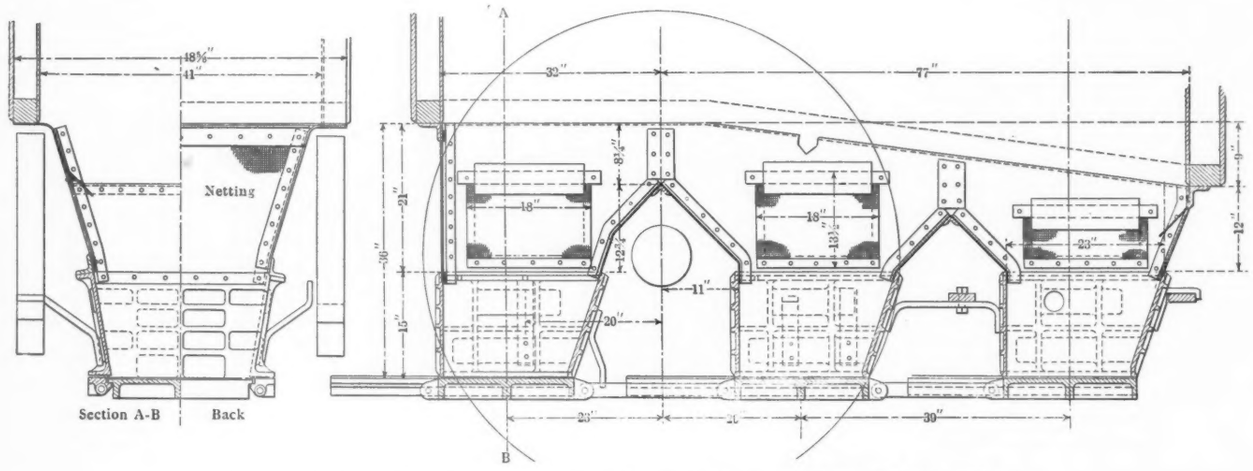


FIG. 1.—HOPPER TYPE OF ASH PAN WITH SLIDING DOORS—NORTHERN PACIFIC RAILWAY.

THE HOPPER TYPE.

Sliding Doors.—The ash pan shown in Fig. 1 is a design which has been in use for a number of years on the Northern Pacific and has proven to be entirely satisfactory. The arrange-

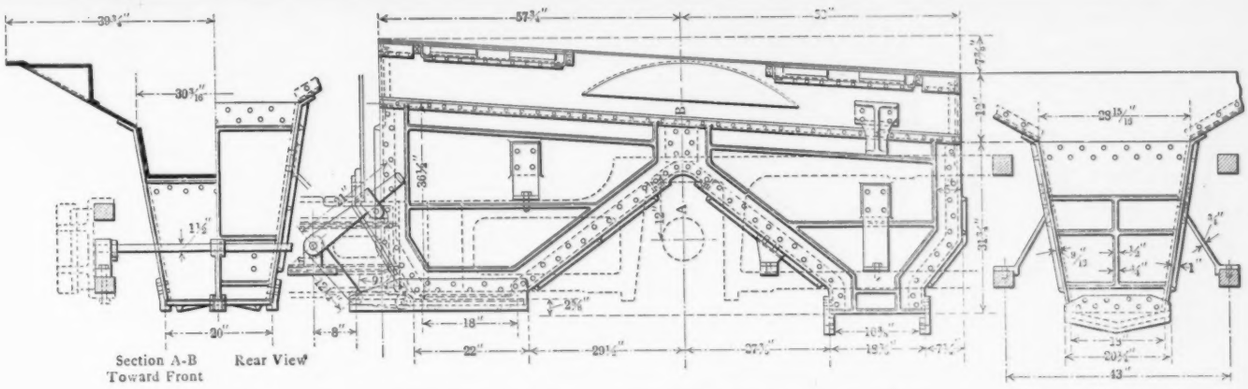


FIG. 2.—CAST IRON ASH PAN—CENTRAL RAILROAD OF NEW JERSEY.

ment, of course, is varied for different classes of engines, two hoppers being used instead of three in some cases. The pan proper is made up of sheet metal in the usual form, liberal air openings covered with netting being provided. The hoppers themselves are of cast iron or steel about 15 in. deep. The frame forming the guide bolted to the bottom of the hopper is cored out for its full length and tapped at the end for the introduction of a ¾ in. pipe. Several small holes are drilled from this cored passage to the bearing of the slide and steam for thawing out a frozen slide is introduced in this way. The sliding wedge on the guide castings, which forces the doors to a tight bearing against the bottom of the hopper after they are in a closed position. This feature also permits them to be given more clearance in the guide than would otherwise be advisable.

The ash pans on the Chesapeake and Ohio Railway are built up of steel plates, liberal provision for air openings being made in the upper sections. The hoppers proper are separate from the upper part of the pan, so that they can be removed and repaired or renewed as they become unsafe. A cast steel hopper bottom and slide or door is used on this road, the details of which are

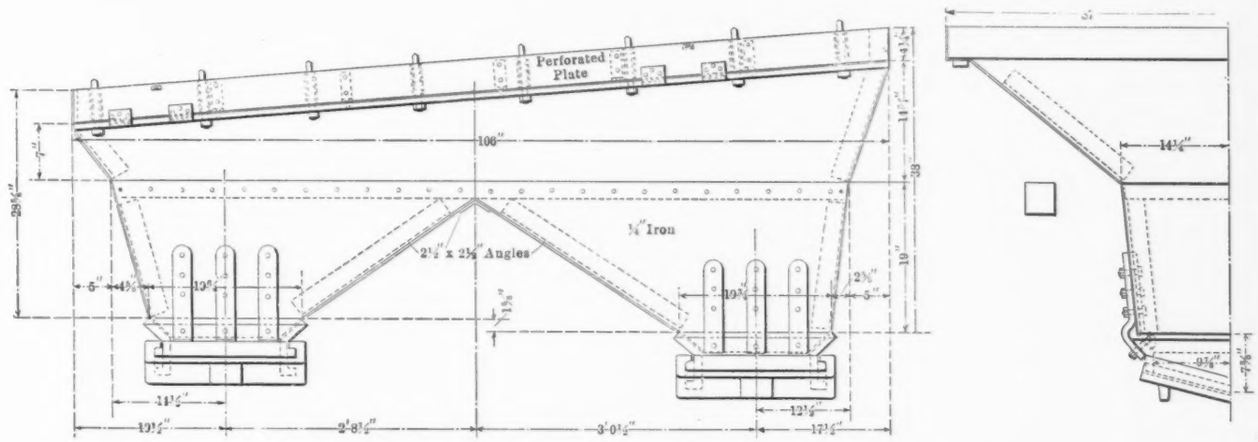


FIG. 3.—HOPPER TYPE OF ASH PAN—CENTRAL OF GEORGIA RAILWAY.

doors are of cast iron chilled on their bearing surfaces and deeply ribbed to prevent warping. All three doors are operated together, the operating mechanism connecting to each side of each door, thus preventing them getting cocked and binding.

Figure 2 shows a pan applied to Wooten fireboxes on the Central Railroad of New Jersey, which is largely constructed of cast iron. It has two hoppers, the rear one having a door sliding in a longitudinal direction and the front one, double doors each set on an incline and sliding in a lateral direction. The front hopper has no operating gear.

A design similar to this front hopper is used on the Lehigh Valley Railroad for both hoppers of pans on Wooten firebox locomotives. In this case, however, the pan is built up of steel plates, a casting being riveted on the bottom of the hopper to form the guide. The double sliding doors are arranged to hook over the guide on the frame instead of sliding in a slot. Almost identically the same design is also used on wide firebox locomotives on the Central of Georgia Railway, the details being shown in Fig. 3, and it is also standard on the Philadelphia & Reading Railway.

The ash pan used on culm burning locomotives on the lines of the Delaware & Hudson Company has two hoppers fitted with longitudinal sliding doors operated together by one gear, the connections between the doors being triple. A feature of this design which is admirable is the arrangement of an incline or shown in Fig. 4. All of the slides are operated from one shaft at the rear, the connecting links being of 2¼ x 1 in. bar. A somewhat similar type of door is used on the Norfolk and Western Railway, the slides, however, in this case being formed of 3 x 2 x 9/16 in. angles riveted to the bottom of the hoppers. The doors are fitted loose, a play of ⅜ of an inch being allowed between the bottom of the hopper and the top of the door. The doors in this case are operated by an air cylinder, which is supported directly back of the rear hopper and has its piston connected directly to the door of this hopper. A stop is provided

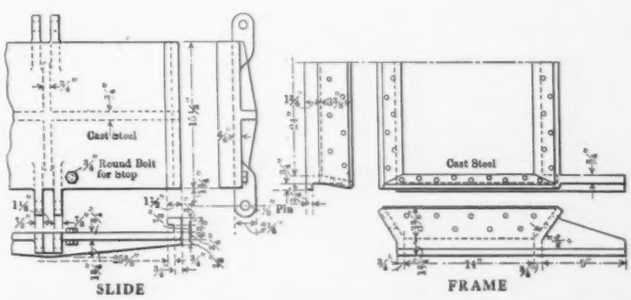


FIG. 4.—CAST STEEL ASH PAN SLIDE AND FRAME—CHESAPEAKE AND OHIO RY.

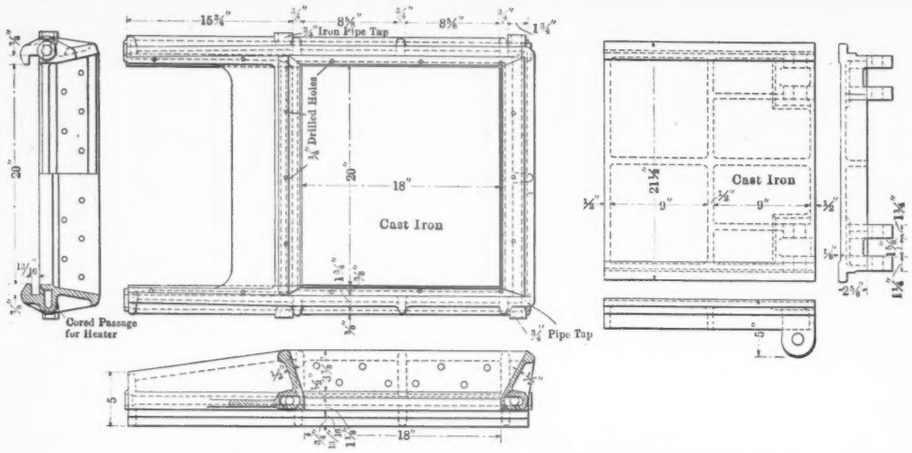


FIG. 5.—CAST IRON ASH PAN SLIDE AND FRAME WITH HEATING PASSAGES—BALTIMORE AND OHIO RAILROAD.

on the front hopper which prevents the piston striking the head of the air cylinder. A lock, consisting simply of a pin inserted through a hole in one of the angle irons in the bottom of the hopper and projecting down back of the slide, prevents the doors being opened accidentally. This arrangement has been in successful service on this road for several years.

On the Baltimore and Ohio Railroad a design of hopper frame and guide and sliding door, shown in Fig. 5, is used. This frame is provided with a cored passage all around the hopper opening with small vents to the slide bearing. The ash pans on this road are very liberally provided with nettings and have the hopper section constructed so as to be easily detachable. Double connecting rods connect all of the slides to one operating lever. A very similar design is employed by the Canadian Pacific Railway, the principal difference being that in this case the slides on each hopper are operated independently. This design is, however, still in the experimental stage on that road.

A double sliding door, operating laterally, is used on the Galveston, Harrisburg and San Antonio Railway on two-hopper ash pans. The two doors on each side of the locomotive are operated by an air cylinder through cranks and connecting rods. The arrangement is such that the doors are held closed by gravity in case of the failure of any of the connections.

A design for a hopper type of pan about 18 in. in depth which is being applied to six wheel switching locomotives on the Michigan Central Railway, is shown in Fig. 6.

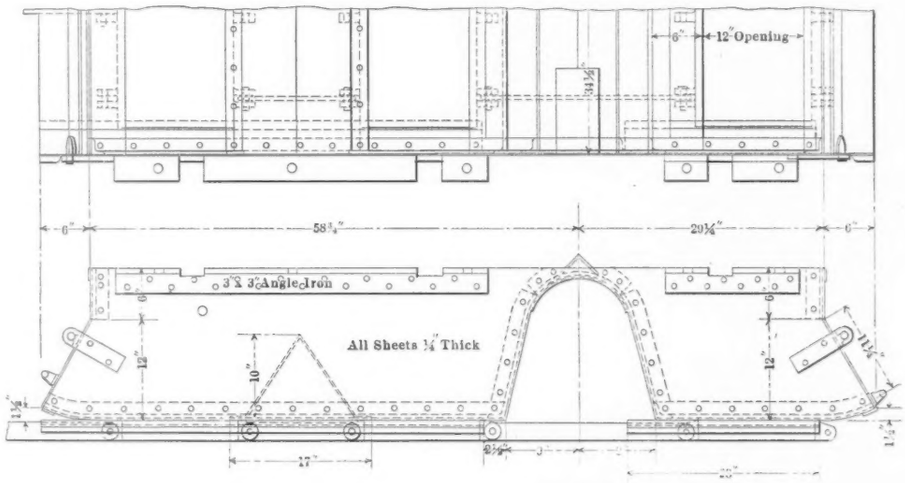


FIG. 6.—ASH PAN FOR SIX-WHEEL SWITCHERS—MICHIGAN CENTRAL RAILWAY.

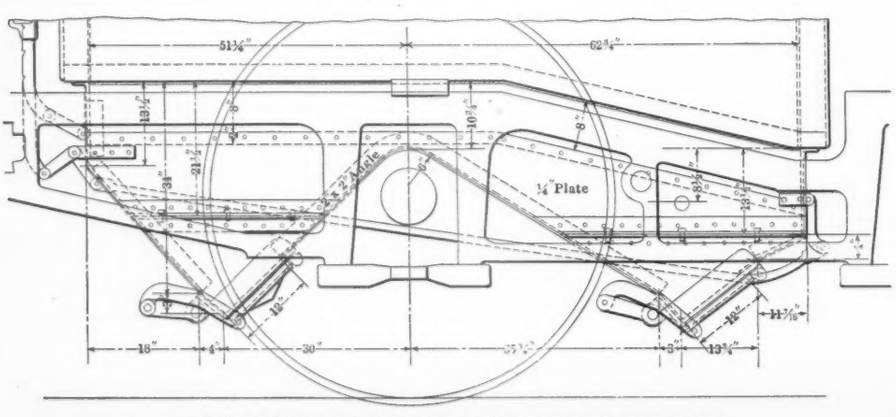


FIG. 7.—ASH PAN WITH HINGED DOORS—WABASH RAILROAD.

Other railroads using the hopper type of pan with sliding doors all have designs which closely approach some of those already mentioned, the arrangement of the steam pipe around the hopper frame and guide being quite generally used on lines in cold climates.

The general plan seems to be to operate all of the slides or doors from one operating mechanism, the connecting rod normally being double, one on either side, between the different doors. Cast steel frames are used in a number of cases and in a few cases the slides themselves are made of cast steel. The usual custom is to form the hopper section of the pan separately from the upper and wider section and in several cases to form each hopper separately, the connections being made by angle irons on each part. Power operated slides are not as numerous as those arranged to be opened by hand levers. Adjustable dampers are applied but infrequently, the usual custom being to have liberal air openings in the sides and ends of the pan, near the top, which are covered with netting.

Hinged Doors.—Figure 7 shows a design of ash pan of the hopper type for hinged doors, which has proven very satisfactory after a long service on the Wabash Railroad. It will be seen that the operating gear, independent for each hopper, is so arranged that when the doors are closed they are also practically locked and the strain, due to the weight of the contents against the door will not force it open in case the operating lever becomes unlatched. This feature has caused considerable trouble with this arrangement of ash pan doors on many railroads where the doors have been held in place entirely by the locking of the operating lever.

The hinged door type of pan has been in quite general use for a number of years and in some cases has proved to be very satisfactory. The chief objection to it seems to have been the difficulty of keeping a tight joint after the doors have become somewhat warped and this has been held responsible for a number of disastrous fires on bridges and trestles.

Swinging Doors.—This arrangement for closing the bottom of

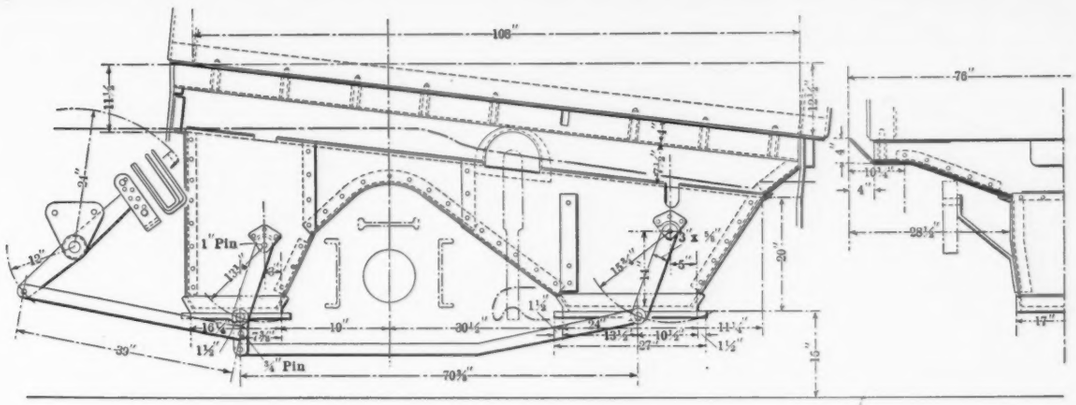


FIG. 8.—ASH PAN WITH SWINGING DOORS—CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY.

the hopper ash pan has many features of advantage and has been used with considerable success on a number of roads. Figure 8 shows the design on the Chicago, Milwaukee and St. Paul Railway, the construction of which is clearly shown in the illustration. The chief objection that can be brought against this arrangement is that the accidental unlocking of the operating lever permits the doors to swing open by gravity. A design on the same principle is in use on the Great Northern Railway. The pan in this case has cast iron hoppers of the same general design as illustrated in Figure 1. In this arrangement the operating lever is fitted with a pawl working in a tooth quadrant, which it would seem to be almost impossible to accidently unlatch and which will also permit the doors being brought to a tight bearing after the pins are worn or the connecting rods bent. The rod connecting the operating lever with the equalizing link in this case is fitted with a turnbuckle for adjusting its length to suit the notches in the quadrant.

The Central Railroad of New Jersey is using an ash pan with cast iron hopper which has swinging doors of this same general design, as is also the Lake Shore and Michigan Southern Railway, where the design shown in Figure 9, applied to consolidation locomotives, has been found to be very successful. In this case the hoppers are made of cast steel, which permits them to be straightened and put back into service after they have become badly warped. Cast iron sections which were first tried become warped and cracked beyond repair.

Special Arrangements.—A radial door type of hopper ash pan, shown in Figure 10, has been in use for some time on the Buffalo, Rochester and Pittsburgh Railway, and has proven to be very successful. This type of door will remain in the open or closed position by gravity. It can easily be swung open and is not in operative when frozen. The frame is made of cast steel, the door is of cast iron and the shaft bushings are of malleable iron. Each door is operated independently, as shown. A patent has been applied for on this device.

A swinging gate type of pan, shown in Figure 11, is in use on the Atlantic Coast Line. In this the gate or valve closing the bottom of the hopper is made considerably larger than the opening and thus avoids any trouble with distortion of the pan or valve and also allows it to overlap the edges at the bottom of the hopper, so as to form what might be called an "ash seal." The arrangement of the operating lever is such that in its closed position the short arm of the bell crank has passed the dead

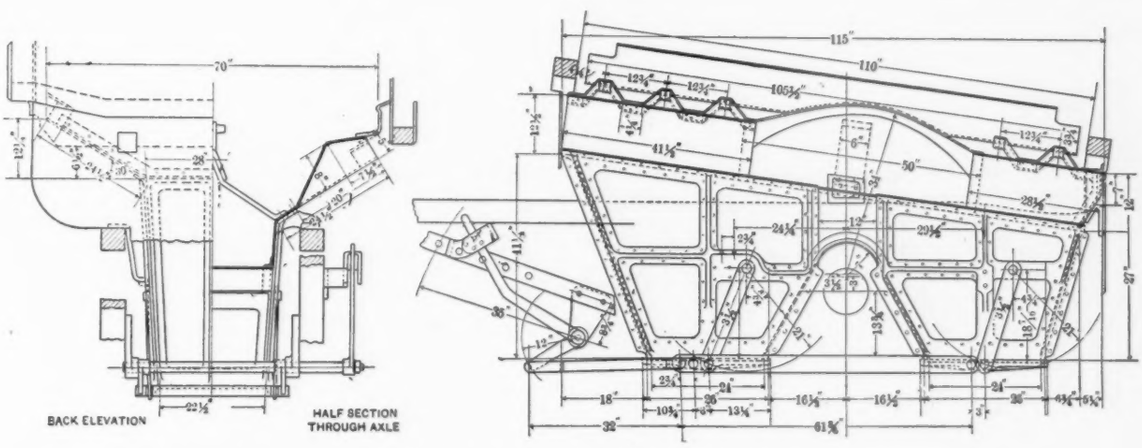


FIG. 9.—CAST IRON ASH PAN WITH SWINGING DOORS—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

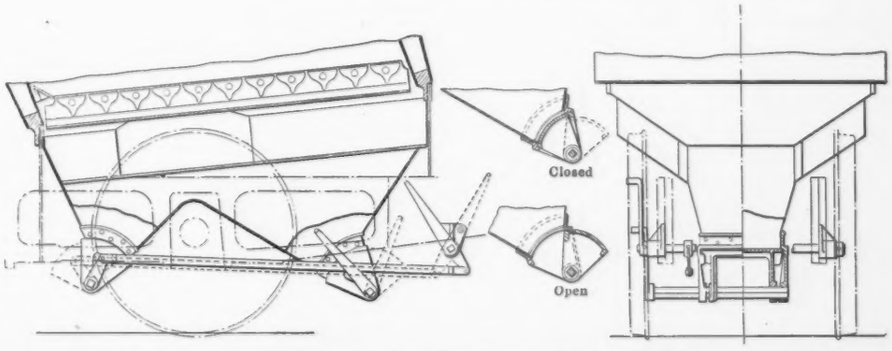


FIG. 10.—ASH PAN WITH PATENTED RADIAL DOORS—BUFFALO, ROCHESTER AND PITTSBURGH RAILWAY.

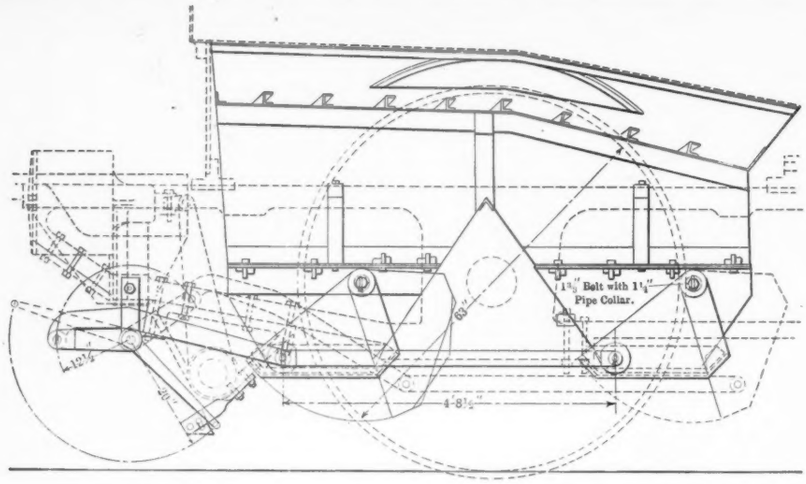


FIG. 11.—ASH PAN WITH SWINGING GATE—ATLANTIC COAST LINE.

center and any tendency of the valve to open by gravity is resisted in this way.

A hopper design of ash pan having a closed flat bottom and vertical hinged doors at the end is used on the Mobile and Ohio Railroad. The contents of this pan are discharged by a steam blower set in the forward end on the bottom of the pan, there being a single nozzle in each hopper. The connection to the blowers is through a 1¾ in. pipe.

Shallow or Flat Ash Pans.

Blower Discharge.—The most generally adopted method of complying with the new law in the case of shallow ash pans has been by the introduction of steam jets which force the contents of the pan through an opening at the rear. One method of doing this which is in use on the Illinois Central Railroad, is shown in Figure 12. A 1¼-in. pipe with four nozzles, consisting of the same size pipe flattened down to a ¼-in. opening, is placed in the front end near the bottom of the pan, and connected to the bottom of the boiler ahead of the firebox, at which point a globe valve is provided. At the back end of the pan a shield or guide is fitted for forcing the discharging contents down into the cinder pit, and preventing them from being blown back on the tender truck. Practically the same thing is used on the Atlantic Coast Line for shallow pans, except that in this case the nozzles consist simply of a piece of ¾-in. pipe with a reducing bushing.

On the Central of Georgia Railway the same idea is employed, a difference, however, being made in the shape of the pan, which is curved on the bottom instead of flat and has one nozzle located near the bottom in the center and one at either side on a higher level. The pan in this case is 16 in. deep in the center.

On the Norfolk and Western Railway a plan is being tried which incorporates a series of cross pipes at the bottom of the pan, as is shown in Fig. 13. These pipes, as at first tried, were ¾ in. and had a series of 3/16 in. holes drilled in the forward side. Cast iron shields were provided back of each pipe, as is shown in the illustration. The arrangement as shown, however, did not prove to be entirely satisfactory and larger pipes are now being experimented with.

Sliding Doors.—Figure 14 shows a sliding door type of shallow ash pan which is in use on the Illinois Central Railroad. This pan is formed with a cast iron bottom which has three openings 10 in. wide for the full width of the pan. These are covered by sliding gates of the shape shown in the illustration operated by connecting rods, one on either side. A pair of ¾-in. heater pipes are provided along the bottom, one on each side of the pan. An arrangement of sliding doors with the shallow pan is used on the Galveston, Harrisburg and San Antonio Railway, which is practically self-clearing. The doors are double, and the pan is formed into three very shallow hoppers having openings 17 x 19½ in. The sliding doors are made of plates and work in cast iron guides. They are operated by air cylinders, one on either side of the locomotive. Another type which approaches this same principle is in use on the N. C. & St. L. Ry. and is shown in Fig. 15. The arrangement in this case is clearly shown in the illustration. The pan is tight in every particular, swinging dampers only being provided for air inlets. The doors are continuous for the full length of the pan and are connected to the operating cranks at two points.

Side Opening Pans.—A design of ash pan has been applied by the Boston and Maine Railroad which simply provides openings

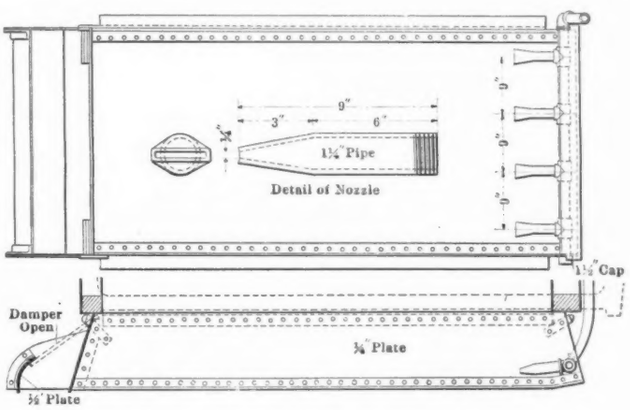


FIG. 12.—SHALLOW ASH PAN WITH BLOWERS—ILLINOIS CENTRAL RAILROAD.

closed by slides in the side of the pan, and the contents are discharged by men standing outside of the engine and using a hoe.

Special Arrangements.—A self-clearing arrangement of shallow pan, designed on a very novel principle, is in use on the Chesapeake and Ohio. This might be termed a shutter type of ash

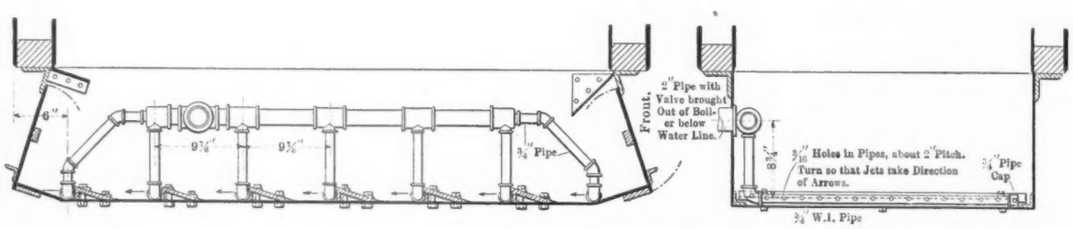


FIG. 13.—SHALLOW ASH PAN WITH A SERIES OF BLOWERS—NORFOLK & WESTERN RAILWAY.

pan, in that the bottom of the pan is formed of a series of cast iron shutters somewhat approaching a rocking grate in general principle, except that they are not provided with fingers. Each swings around trunnions resting in side bars on the bottom of the pan. They are operated by short arms projecting up at one end and connecting to bars in the same manner as grates are con-

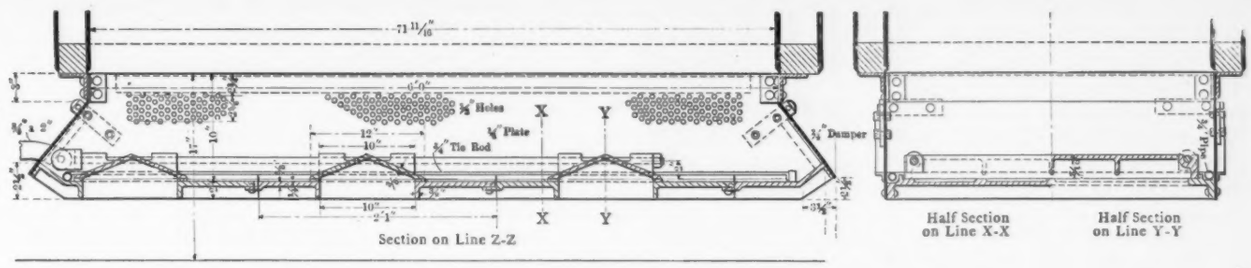


FIG. 14.—SHALLOW ASH PAN WITH SLIDING DOORS—ILLINOIS CENTRAL RAILROAD.

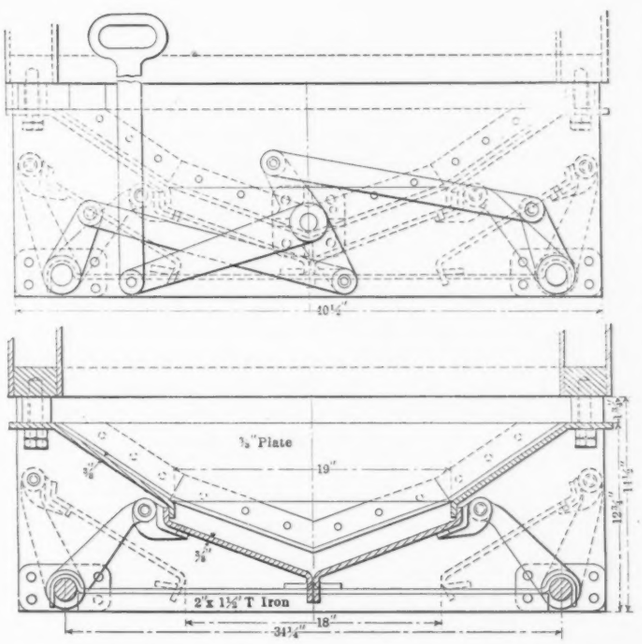


FIG. 15.—SHALLOW ASH PAN WITH LONGITUDINAL SLIDING DOORS—NASHVILLE, CHATTANOOGA AND ST. LOUIS RAILWAY.

nected. When the operating lever is moved the shutters will discharge the complete contents. This design has proven to be satisfactory in practice.

EXPERIENCE WITH THE JACOBS-SHUPERT FIREBOX

TO THE EDITOR:

The letters to your journal in reference to the new sectional type of firebox designed by Jacobs and Shupert have been so positive both pro and con of the advantages and disadvantages in the new type of construction, and the advantage claimed by one person having been considered a disadvantage by another party so positively, that I should like to clear away the mists and present some of the facts already developed in actual operation.

I have been in a position to watch the operation of this firebox in light and heavy service, having ridden on it half way across the continent and having observed it in actual service pulling 1030-ton trains up 1.8 per cent. grades. Up to the present time the firebox has proven a decided success, having already fulfilled many of the claims made for it on the part of its inventors; at this time it promises to make good on additional claims hardly anticipated during its construction.

The circulation in this firebox has been the cause of a great deal of comment. An authority of high standing, after having watched the temperatures of the water in the different portions of the boiler, in which thermometers were placed, was astonished at the results shown, and remarked that the circulation was either very poor or it was better than anything in water circulation that he had ever seen or conceived. Observations made since that time have confirmed his conviction that the circulation is far superior to that in the ordinary firebox.

The class of engine to which this boiler is applied is used by the Santa Fe for heavy duty freight service in the mountainous desert districts where the grades are heavy and the water is bad. The fuel used is California oil, and the length of the district is 148 miles from Needles, Cal., to Seligman, Ariz. The schedule time is eleven hours for certain classes of freight. There is a rise of 5,010 feet in 125 miles, much of the grade being 75 and 95 feet per mile.

After having pulled a heavy load for 11 to 13 hours on one day, one of these locomotives is called upon the next day to take a 20 per cent. greater load down the mountain when drifting conditions tend to be most destructive upon the life of the engine because of the almost instantaneous change from extremely heavy to very light service. Moreover, these engines are subject to unavoidable changes in temperature in the firebox due to the fact that they are oil burners. The temperature in the firebox is several hundred degrees higher than that in a coal burner. As soon as the engine pulls over a hard grade and starts to drift the oil is shut down and the cold air rushes in, tending to cool the box with great rapidity. In coal burning engines these severe conditions, due to temperature changes, do not exist, due to the radiation from the glowing coals.

In the October, 1908, issue of your journal there is a remarkably clear, comprehensive and practical article on "Care of Boilers at Terminals," by J. F. Whiteford. This article shows graphically the temperature changes in the boiler with an ordinary firebox due to different methods of handling. The first exhibit shows that there is a change of temperature of 210 degrees due to use of injector while standing. Thermometers inserted in the same relative positions show that the temperature change is not over 60 degrees, under same conditions for Jacobs-Shupert firebox. During a period of operation the water does not vary over 10 degrees in different portions of the firebox, above the brick work. This constancy in temperature is wonderful to note and means a great deal in prolonging the life and eliminating the repair work of the firebox.

Under adverse conditions, with heavy load on a hard grade, with bad water very liable to foam and without blowing out, as is done in regular practice, engine 917 equipped with the Jacobs-Shupert firebox, carried her water extremely well and never was on the point of raising it. This fact of operation is a proof of the practicability of the firebox.

The liability of the sections to change shape has been a much mooted point and the argument has been advanced that the vibration of the firebox due to temperature variations will break the stay sheets. Now the design is such as to prevent all vibration of the stay sheets, the sectional construction taking up all expansion and contraction and producing no stresses on adjacent sections.

The design has met with the approval of nature and natural forces. A template was constructed that conformed with extreme accuracy to the contour of several sections of the inner portion of the firebox most susceptible to change of form. After experiencing hard service the firebox was examined and found to be in absolutely perfect condition, not a leak developed, the mud-ring construction was firm and true, and the template showed absolutely no permanent change in the contour of the sections.

An inspection showed no accumulation of sediment in any portion of the boiler. The inspection also showed that there is still much truth in the old saying, "Do not cross a bridge until you get to it." "Circulation" has been losing lots of sleep for fear that much scale would form on the rivets, he may as well nap a bit, for after five weeks there has been absolutely no scale found on the rivet heads, in fact there is no tendency thus far for scale to form either on the rivet heads, on the outer walls, or on the stay sheets.

Mr. Wood on page 201 of the May issue evidently has had a different experience regarding incrustation. The only explanation that seems reasonable is that he has a different kind of a firebox, one not eliminating fully enough the objectionable features of the ordinary construction. This fact is perhaps more forcibly made evident upon consideration of the staybolt problem.

He emphasizes the fact that his construction eliminates as many as 350 staybolts in a single firebox. In the firebox displaced by the Jacobs-Shupert there are 902 staybolts on the sides, 390 in the door sheet and 336 radial stays in the crown sheet; the grand total is 1395 staybolts, and 336 radial stays. In the Jacobs-Shupert firebox there are 312 staybolts in the door sheet and 110 in the flue sheet; the sum is 422. There is an elimination of 973 staybolts and 336 radial stays. Moreover, the length of the Jacobs-Shupert firebox is 21 inches greater than the ordinary. Figured on the elimination of staybolts for the same length of firebox, we find that the Jacobs-Shupert firebox dispenses with 1125 staybolts and 400 radial stays.

In the latter construction there are 1764 rivets for the inner and 1204 rivets for the outer portion, a total of 2968 rivets.

The steam pressure carried is 225 pounds which involves the highest stresses the firebox will ever get in practical service; the water used is very hard on boilers; the service is excessively hard and necessitates a boiler being in fine condition at all times.

This engine carries her water exceptionally fine. It is able to hold 4 and 5 inches of water in the gauge glass when other engines of her class can carry scarcely 1 inch. The improved circulation in this boiler allows the water to keep comparatively clear in the top of the boiler while impure in the bottom.

The positive assertions of Mr. Wagstaff in the last issue of your journal on the perfect water circulation in this firebox have been fulfilled to a letter. His keen judgment and his extensive practical experience enabled him to predict with great accuracy on the essential points in the operation of this firebox.

NEEDLES, CAL. H. P. MACFARLAND.

FLANGE WEAR OF DRIVING TIRES.

BY R. H. ROGERS.

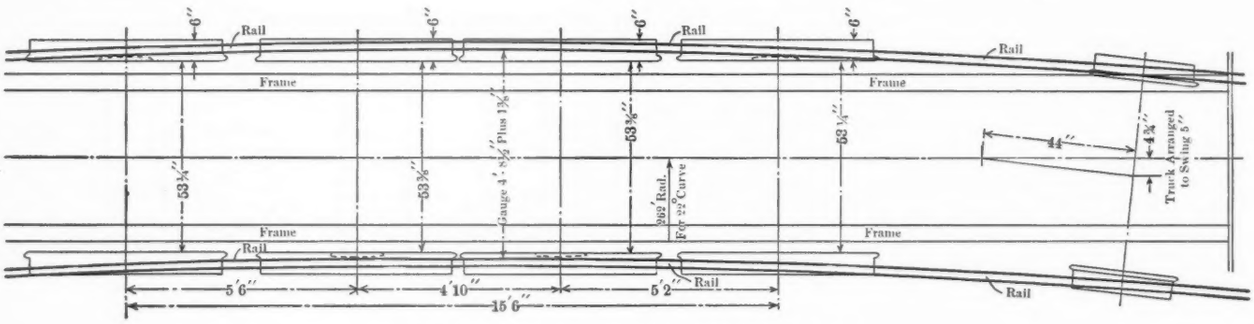
That the subject of flange wear on locomotive driving wheel tires has not been given more attention by the various railroad clubs and other railway mechanical associations is surprising in view of the fact that on many roads it has grown to be an important feature of expense which is well worthy of careful investigation. When it is considered that driving tires often have to be changed in three months from the date of application, and there are instances where they have been condemned in six weeks time because of sharp flanges, certainly an intelligent sifting of this troublesome detail should afford interesting material for discussion which can not fail to be of general interest.

The question naturally occurs, "Can flange wear be eliminated?" Some roads have such a high percentage of curves that flange wear must inevitably ensue to a certain extent, and under such conditions it is no more susceptible of elimination than any other feature of locomotive deterioration, but after extended observation along this line the writer believes that even in extreme cases it can at least be controlled sufficiently to prevent the removal of the tires for turning between each general shopping of the locomotive and that in other cases it can be practically eliminated.

There are certain recognized standards for the spacing of the tires, measured across the engine, for each pair of wheels, and the mere matter of fully living up to these standards, and disregarding all contributing causes of flange wear, will in most cases reduce this trouble fifty per cent. This may appear an extravagant statement, as it would imply that a disregard of standards exists in all cases where tire troubles are in evidence. It should not, however, be so construed, but rather that there is a laxity in the shops in this important regard which escapes the management, who, with the knowledge that prints and instructions exist, thoroughly covering the matter in detail, are often lulled into a false security under the impression that the mere presence of these in the tire gang conveys the assurance that they will be lived up to.

So many errors in the correct setting of tires have been noted on so many railroads, that, in the consideration of flange wear, improper spacing of tires must be assigned as the primary cause. Improper spacing of tires in this sense is intended to mean carelessness in securing the exact measurement from one tire to another, on the same pair of wheels, as laid down in the standard practices.

To illustrate, we will assume a 2-8-0 engine, of 15 ft. 6 in.



CONSOLIDATION LOCOMOTIVE ON A 22 DEGREE CURVE.

rigid wheel base, and having all tires flanged. What may be considered as standard tire setting for this type is:—intermediate and main tires 53⅜ in. apart, measured of course between inside faces of the tires, front and back pair of tires set 53¼ in. apart. Thus the setting on the entire wheel base of this engine would be: No. 1, 53¼ in.; No. 2, 53⅜ in.; No. 3, 53⅜ in., and No. 4, 53¼ in. This arrangement is to relieve the flanges on Nos. 1 and 4 tires while rounding curves of short radius. There is no dispute but that this setting in of the front and back tires is not only permissible but actually necessary. This is well illustrated by the accompanying diagram, which represents this engine laid down on a 22 degree curve, 262 feet radius. Everything is to scale, and both engine and curve are as they actually exist on the Mexican Central Railroad.

This diagram graphically portrays the exact position of each

and every wheel on the two rails. It will be noted, notwithstanding the degree of curvature, that the flanges of Nos. 2 and 3 wheels are evenly against the rail on the low side, and, as that rail is curving away from these flanges, in both directions, it can be readily appreciated that they are not receiving abuse other than what may be expected from natural wear. On the contrary the diagram plainly indicates that the flange of No. 1 wheel, on the high side of the curve, is grinding sharply against the rail, and that the flange of No. 4 wheel, on the same side, is dragging on the rail, although tending to move away from it.

It is this grind of No. 1 and drag of No. 4 flange, assuming the locomotive to be running ahead, or vice versa if running backward, which makes it mandatory that Nos. 1 and 4 tires shall be set closer together than Nos. 2 and 3. To appreciate that this setting in does constitute a relief, it should be borne in mind that Nos. 2 and 3 flanges are practically always against the rail on the low side. The elevation of the curve provides for this, and although the direction of the locomotive is toward the outside rail, it still may be considered as having the flange mentioned always in contact with the low rail, therefore the setting in of Nos. 1 and 4 tires, as in this illustration, tends to relieve their flanges just the amount of the difference made in the spacing.

From this it might be logically inferred that a still further setting in would be of greater advantage, and that the tires on Nos. 1 and 4 wheels could be spaced to advantage as much less than 53⅜ in., which is standard for all intermediate and main wheels, as the guard rails will permit. The face of the guard rail measures 1¾ in. from the stock rail, therefore, on this type of locomotive, which is generally representative, it would permit the setting of the tires on Nos. 1 and 4 wheels at 53⅛ in., and still clear the guard rail 1/16 in. This, as a matter of fact, is a logical and better setting than that in the diagram, and it is standard for engines of this type on many large roads.

From records covering the close inspection of hundreds of engines during the past few years, wherever flange cutting has been in evidence, the writer notes some remarkable variations from standard practices. One instance in particular should be mentioned, that of a 2-8-0 engine, 17 feet rigid wheel base with all flanged tires, which actually had front tires spaced 53¾ in., and, quoting from the report, "⅝ in. wider than spacing for best results, and ⅜ in. wider than any recognized spacing." This is, of course, a somewhat extreme case, but it actually occurred on one of the best handled railroads of the west, simply because the confidence in the tire foreman was misplaced.

Another engine of the same class had tires spaced as follows: No. 1, 53 7/16 in.; No. 2, 53 7/16 in.; No. 3, 53½ in.; No. 4, 53¼ in. Another engine, No. 1, 53⅜ in.; No. 2, 53½ in; No. 3, 53½ in., and No. 4, 53 5/16 in. In this arrangement the first pair of wheels in each engine had tires at least ¼ in. further apart than any recognized spacing, Nos. 2 and 3, ⅛ in. further apart than any practice, :and No. 4 ⅛ in. in excess of the best practice. Another engine had front tires 5/16 in. too far apart, and another ⅜ in. Each of these engines showed pronounced flange cutting. A pleasing contrast, however, was afforded in still another engine of the same type. This had Nos. 1 and 4 set at 53⅛ in., and Nos. 2 and 3 at 53⅜ in., and exhibited no flange wear whatever, or even rubbing, although the tires had been on five months, and the engine had made the same if not more mileage than the others mentioned.

The above examples, while occurring on one road are merely illustrative of what the writer has encountered on several others, and every one of these roads it may be said, had shop practice cards and blue prints covering all necessary information for correct tire-setting. On one of these, which ran through a mountain country, with all the popular causes present against the longevity of flanges, such vigorous action was taken on the portrayal of these conditions that seventy-five per cent. of this abnormal flange wear was eliminated within the ensuing six months. The measures which brought about such a gratifying result were: (1) Replacing the measuring sticks of wood, and other makeshifts which had been in use in the wheel gang, by solid gauges with hardened points, one set for each class of engine, and by impressing on those concerned that they should wake up to the importance of the matter, (2) the issue of clear prints for shop use, giving the standard practice for setting tires on all engines, and (3) providing an inspector to gauge every set of tires after mounting in the wheel shop, and certify on a regular form to the correctness of the setting.

It should not be necessary in a well disciplined shop, such as the one in question undoubtedly was, to require this inspector, but it was nevertheless clearly evident that a better order of things must be brought about, and that speedily, so the check was run until the men were brought to fully realize that there must not be the slightest deviation from the standard measurements.

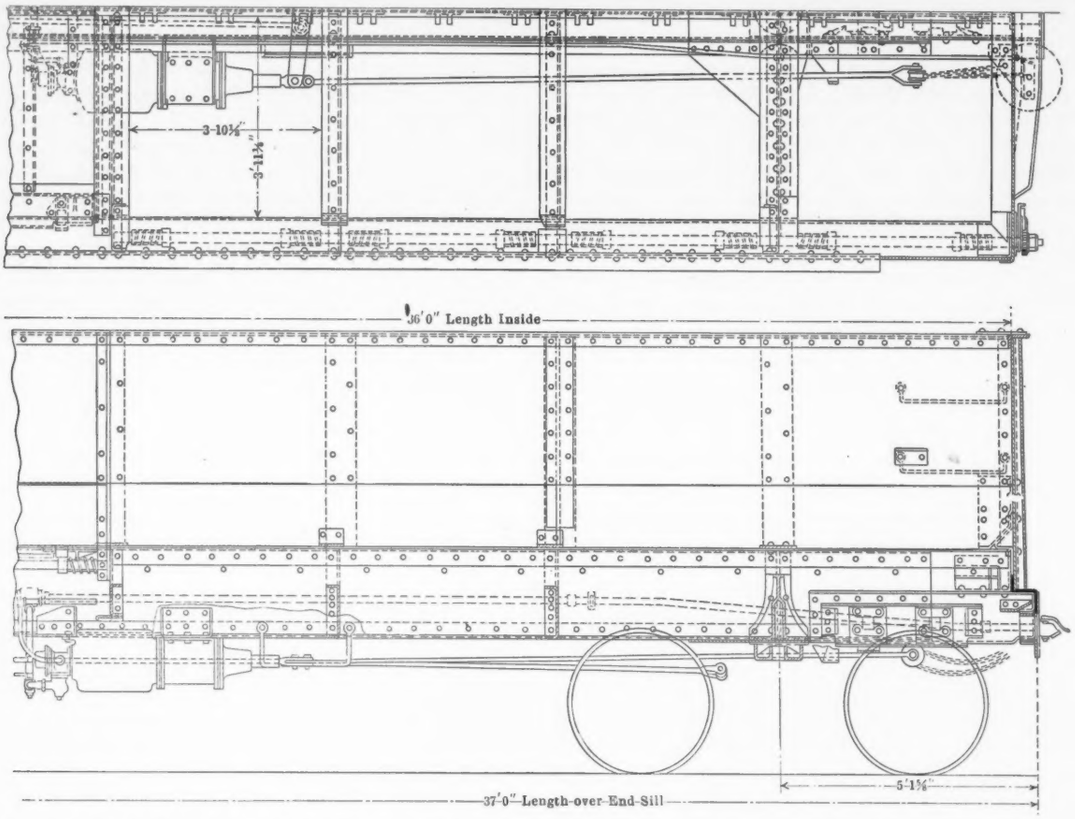
It has been stated that the insistence on attention to the details in the wheel shop will eliminate fifty per cent. of flange troubles, and the writer firmly believes this to be true. The correction of contributing causes must devolve upon the care and vigilance exercised in the roundhouse after the locomotive has been put in service.

First along these lines is to keep within reasonable limits the inevitable accumulation of lateral motion in the engine truck wheels. An excess of this, which should be taken to mean anything greater than ½ in. total, is without question one of the principal contributing causes to flange wear. Excessive end play in the truck wheels results in the leading driving tires being most affected by curves of short radius; in other words, the engine truck does not bear its share of the impact of the curve. When this lateral motion is combined with excessive wide spacing of the front driving tires there could be no other logical result than in excessive flange wear.

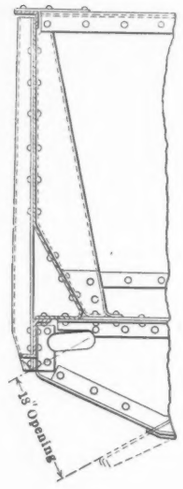
When comment is made regarding excessively worn flanges on any railroad the answer nine times out of ten is that the road or division is so curved that there could be no other condition. It is not the intention to dispute for a moment that roads exist with such curvature that no tires will live on them, but these are exceptional, and the argument would not carry weight unless all engines of equal mileage in the same territory displayed cut flanges. It has come under the observation of the writer that, because of pressure of other duties, and very often also indifference, only a half-hearted attempt is made by those in charge to determine the cause, or even arrive at a sensible conjecture. Occasionally engines cut flanges all along one side, and when these are carefully checked up it is found that they are some lower on the springs on that than on the opposite side; again, the engine may be found not to be properly squared across the pedestal jaws, or not in tram.

Ideal conditions will not have been reached until all wheel centers are standardized, and all tires are bored with a lip. The tire then applied to the center so far as the lip will allow is properly spaced in relation to the one on the opposite side. This is stated with a full realization that should the lip tire plan be adopted, a long time must elapse before the good results which will certainly follow can fully materialize. This is because wheel centers on old engines are frequently at variance with standards; many are too far apart, while some are too close, and in consequence, facing the outside of the rim to bring the standard lip tire to its proper position would have to vary with each individual case. The soundness of the lip tire idea, however, will be readily appreciated by those familiar with the hurry and handicap imposed when tires are changed in roundhouses. The chances for error in the setting of the tires, which are frequently in evidence under such conditions, would entirely disappear, as the tire could only be applied on the center as far as its lip would allow.

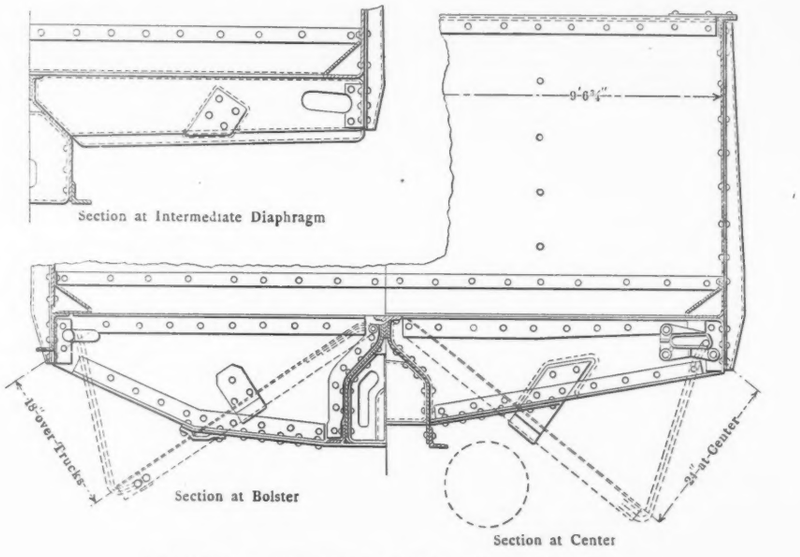
Flange wear is not by any means hopeless of solution. There is scarcely another detail of locomotive maintenance which will yield such a good return from the application of reason and insistence on standards as that of the tires. The writer's extended observations lead to no other conclusion but that it can be successfully combated and relegated to its proper position as a minor, instead of an important item of expenditure, on nine of every ten railroads in the country.



PARTIAL ELEVATION AND PLAN VIEWS OF DENVER & RIO GRANDE GENERAL SERVICE STEEL GONDOLA CAR.



SHOWING SIDE CONSTRUCTION OF D. & R. G. CAR.



TRANSVERSE SECTIONS THROUGH NORTHERN PACIFIC GONDOLA CAR.

GENERAL SERVICE STEEL GONDOLA CARS.

The Denver & Rio Grande Railroad has a large number of general service steel gondola cars equipped with sixteen drop doors, allowing more than 99 per cent. of the lading to be dumped by gravity. When closed the doors are flush, making the car as suitable for shoveling, or general lading, as a plain gondola. While it has all the advantages of a twin hopper gondola, or a hopper car, for carrying such material as coal, coke, ore, sand, gravel, crushed rock and dirt it may be used to advantage for general purposes where there is no material of this kind for the return trip. This feature is also advantageous where a temporary or permanent change of conditions may sometimes render useless cars purchased for a special purpose, such as hauling coal or ore.

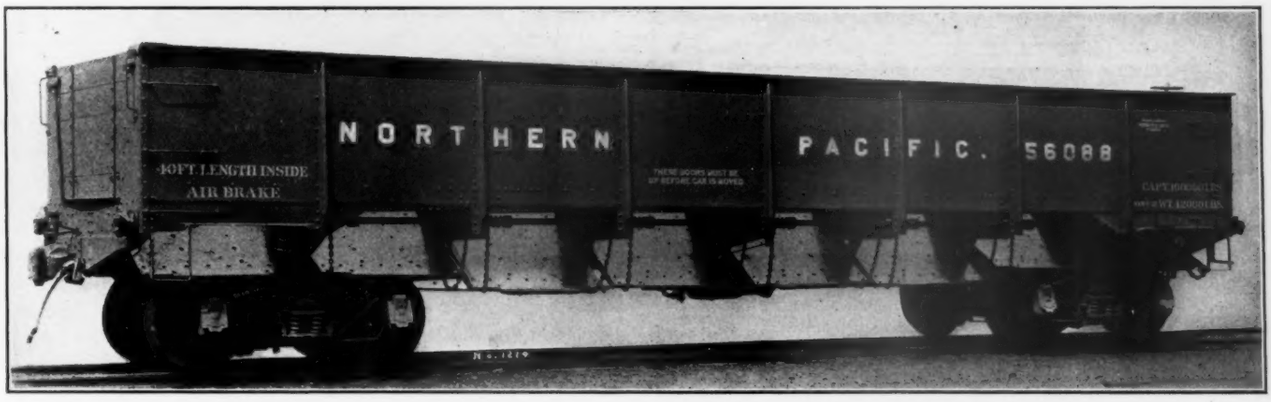
The car is substantially built, it has been developed to its present state by many years of study and experience on the part of the designers and builders, the Pressed Steel Car Company. In order to discharge all the lading by gravity the lower part of the side plate is bent inward, as shown on the cross-section view. Each side is stiffened by seven vertical pressed steel members on the outside and by the three pressed steel members on the inside.

The center construction consists of two plates arranged in a shape somewhat approximating an inverted V, riveted together at the top with the leg of a T iron between them. An angle is riveted along the lower edge of each of these plates. At the bolster they are tied together by a casting and at the cross bearers by pressed steel diaphragms. The cross bearer consists of pressed steel members with a plate riveted at the top.

GENERAL SERVICE 50-TON, 36-FOOT STEEL CAR—DENVER & RIO GRANDE RAILROAD.

D. & R. G. CAR WITH DOORS OPEN.

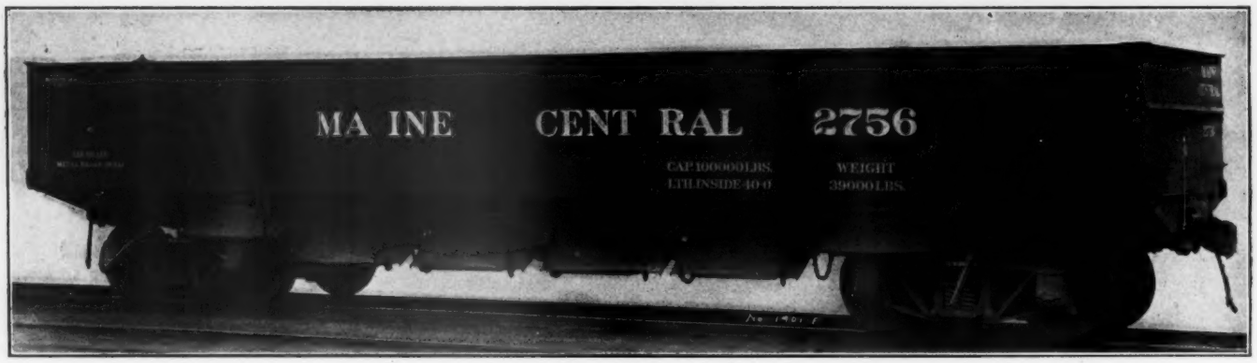
D. & R. G. CAR WITH DOORS CLOSED.



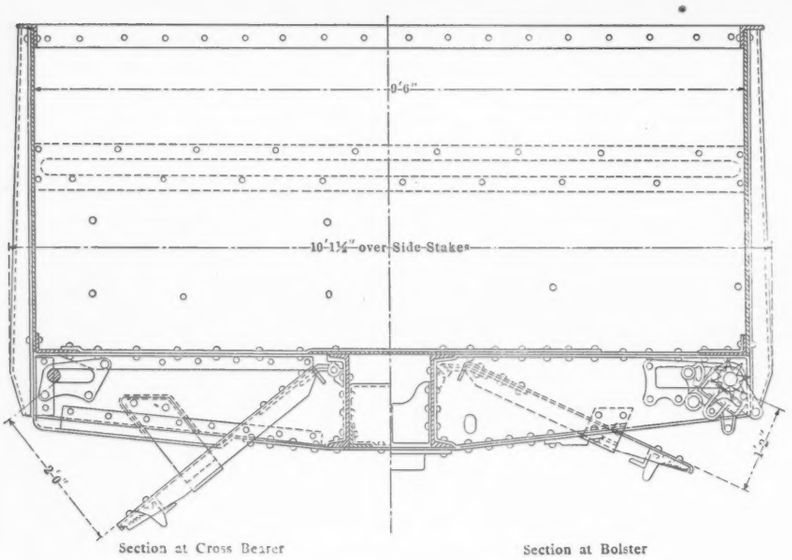
NORTHERN PACIFIC GENERAL SERVICE CAR WITH DROP DOORS OPEN.

At the bolster and at the center of the car these members are reinforced by angles at the top and bottom, as shown.

The doors may be opened or closed in less than two minutes by one man standing either on the ground or the platform. The shaft upon which the chains are wound is operated by a ratchet arrangement at the end of the car; this may be equipped with an operating lever, as shown, or with a socket which can be operated with a bar, a piece of pipe, or a pick handle. After the doors are closed the shaft creeps in under them, supporting them and relieving the chains from the load. Skilled labor is not required to operate them. As an extra check the shaft is locked by a latch and dog at the end of the car. The mechanism is thus simple and positive; the lading cannot be dumped accidently and there is nothing complicated to get out of order.



MAINE CENTRAL 50-TON GENERAL SERVICE STEEL CAR.



SECTION THROUGH MAINE CENTRAL CAR.

One of the illustrations shows a similar car built for the Northern Pacific Railway. Plates are riveted to the sides near the bottom on the inside, and are set at an angle so that all of the lading will be discharged. No inside stiffeners are used for the sides. The car also differs from the D. & R. G. in that it has one drop end of wooden construction, making it suitable for handling long material.

Another of the illustrations shows a car of this type built for the Maine Central, but having only twelve drop doors, those between the ends and bolsters being eliminated. It is thus necessary to shovel a small part of the lading. The car also differs considerably in construction, the center sills being of a box girder type made up of two channels with a top cover plate and with angles riveted at the bottom between the bolsters. General data for these cars and for a similar car for the Frisco, described on page 138, April, 1906, issue, are as shown above.

ROAD	D.& R.G.	Nor. Pac.	Maine Cen.	Frisco
Capacity	100,000 lb	100,000 lb	100,000 lb	100,000 lb
Length Inside Body	36′—0″	40′—0″	40′—0″	41′—9″
Length Over End Sills	37′—0″	41′—0″		42′—9″
Width Inside	9′—6¾″	9′—6¾″	9′—6″	9′—6¾″
Width Over Side Stakes	10′—2¼″	10′—2¼″	10′—1¼″	10′—2″
Height Inside	4′—2″	4′—2″	4′—4″	4′—4″
Rail to Top of Sides	9′—0¼″	9′—2¼″	8′—1¾″	8′—9″
Number of Drop Doors	16	16	12	16
Width of Doors	3′—11⅛″	4′—0½″	3′—1¾″	4′—2½″
Length of Doors	3′—10⅛″	4′—5⅛″	4′—1¾″	4′—10″
Width of Clear Door Opening, Center	27″	24″	24″	26″
Width of Clear Door Opening, Bolster	18′	18″	14″	23″
Distance Between Truck Centers	26′—8¾″	29′—8¾″	28′—9″	31′—0″
Weight	40,500 lb	42,000 lb	39,000 lb	40,300 lb

AMERICAN RAILWAY ASSOCIATION.—At the spring meeting, held in New York on May 19, F. A. Delano was re-elected president; W. G. Besler, second vice-president, and T. E. Clark and G. L. Peck members of the executive committee. There were 158 delegates present. The next meeting will be held in Chicago on November 17.

GAS PRODUCER TESTS.—A series of gas producer tests is now being conducted in the mechanical engineering laboratory of the University of Illinois. The object of these tests is to provide impartial data on the efficiency and operation of small producer plants, using different grades of anthracite coal. An elaborate line of investigation has been planned, the results of which will be available during the coming summer.

COMMON STANDARD STEEL PASSENGER CARS.—We know what the history of the wooden freight car was in years past when every master car builder in the country had his own peculiar notions, adding to the difficulty of getting standard cars. I trust that we have advanced sufficiently to get away from that hair-splitting principle that was carried out in those days and that as the steel passenger coach comes into service there will be a standard, at least of the cross section, so that railway companies that want six or more coaches will be able to buy from builders at a price as favorable as the road that orders 100 cars or more.—*E. A. Miller, Central Ry. Club.*

OIL BURNING LOCOMOTIVES must be used on railway lines through the Adirondack forests, according to an order recently issued by the Public Service Commission of the Second District of New York. The order is an outgrowth of the forest fires of the fall of 1908. From the evidence submitted in the case, the Commission concludes that about 40 per cent. of the land burned over in the Adirondacks during the fall of 1908 was by fires set from locomotives. An investigation was made of the possibility of introducing electricity for the operation of the lines, but this was found to be financially impracticable, and it was therefore decided that the only feasible plan of preventing fires was to adopt oil burning locomotives. The order of the Commission requires that the locomotives used between April 15 and November 1 in each year, between the hours of 8 P. M. and 8 A. M., shall be required to burn oil in the generation of steam. Locomotives burning coal anywhere in the Adirondack preserves must be subjected to the inspection of the Commission, and may not be used until a certificate is issued after such inspection by the Commission's authority. The equipment with oil burning apparatus must be completed not later than April 15, 1910, and at least two locomotives on the Mohawk & Malone R. R., and two on the Delaware & Hudson R. R. must be equipped and in service with oil burning apparatus not later than July 15 of the present year.

COMPARATIVE TESTS OF WATER TUBE AND STANDARD FIREBOXES.

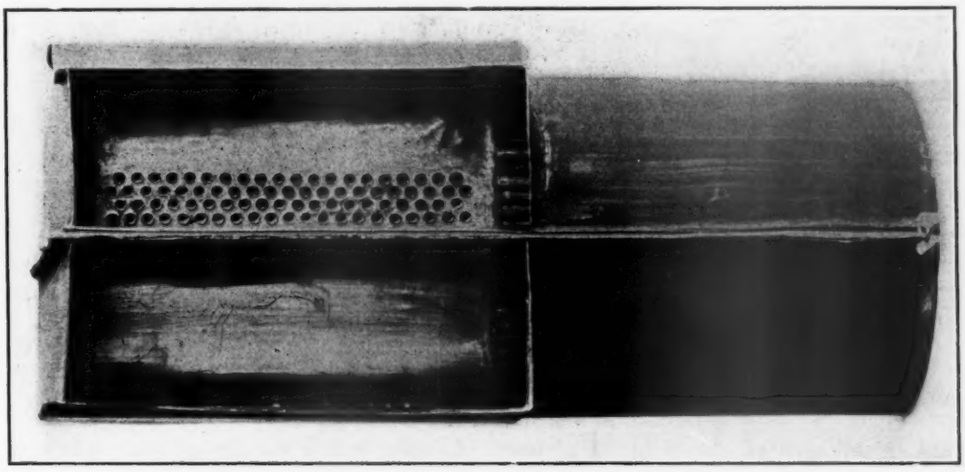
S. S. RIEGEL.

[EDITOR'S NOTE.—On page 136 of the April, 1906, issue of this journal appeared an illustrated description of a water tube locomotive firebox designed and patented by Mr. Riegel, which, on account of its novelty and many evident advantages, attracted considerable attention and comment from our readers. It consisted, briefly, of replacing the mud ring of a wide firebox type Belpaire boiler with a large hollow steel casting which forms the lower terminus or drum for a nest of water tubes extending diagonally upward to the crown sheet, which is depressed in the center in order to keep the upper tube terminations flooded. These nests of 2½ in. tubes are set four deep, the rows extending the full length of the firebox, being so located as to permit the introduction between them of a boring bar, or other tools, for the removal or installation of stayboits in the water leg. Spaces are also left at the front and back firebox sheets for easy inspection. The cast steel lower drum is provided with hinged doors to permit the introduction and expanding of the water tubes.]

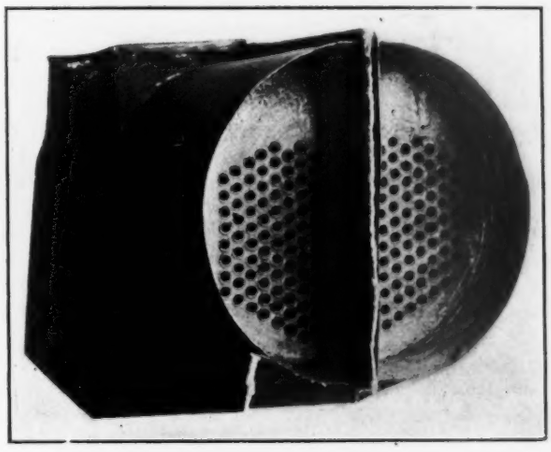
In order to determine exactly what could be expected from a boiler fitted with my type of water tube firebox in comparison with the ordinary standard firebox of the same size, at least as far as increased evaporation was concerned, I recently had constructed some models accurately made to a 1-in. scale, which are shown in the accompanying illustrations. These models are each a half section of a boiler fitted with my firebox and a half section of a boiler arranged with the ordinary standard firebox, the two sections being identical in all respects possible, but each being entirely independent as far as the water circulation is concerned. The principal difference in the two consists in the mud ring, arrangement of the crown sheet, the introduction of the water tubes and the addition of ten extra tubes in the barrel of the water tube design. The design of this firebox permits this increase in the number of fire tubes in the barrel. The two halves were secured together in the manner shown, there being a one-quarter-inch asbestos insulation placed between them in order to prevent the transfer of heat from one to the other. In this way the firebox was common to both halves and the amount of heat received from the fire was the same for both designs. The model was constructed without an outside crown sheet and the tests were all made at atmospheric pressure. In this way the actual circulation of the water around the firebox was accurately observed.

The models had the following dimensions:

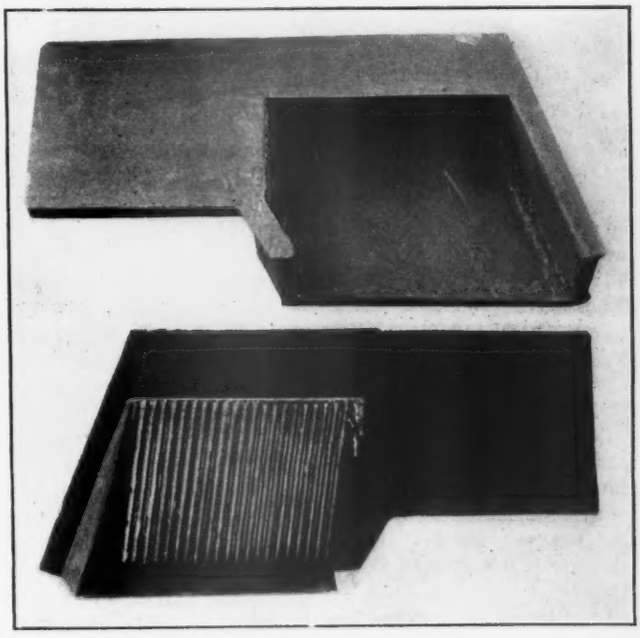
	Water Tube.	Standard.
Grate area (6 x 9¼)	55.5 sq. in.	55.5 sq. in.
Water Heating Surface—Firebox	246.5 sq. in.	242.8 sq. in.
Water Heating Surface—Watertubes	590.5 sq. in.	——
Water Heating Surface—Firebox: Total	837. sq. in.	——
Water Heating Surface—Flues	1009. sq. in.	904.8 sq. in.
Heating Surface—Total	1846. sq. in.	1147.6 sq. in.
Or for complete boilers	3692. sq. in.	2295.2 sq. in.
Weight Empty	25 lbs.	16 lbs.
Weight Full (24 half pints)	37 lbs.	28 lbs.
Percentage of increased heating surface	60%	
(For boiler with full length of flues	40%)	
Percentage of increased weight—empty	56%	
Percentage of increased weight—full	32%	
(For full-sized boiler	20%)	



VIEW LOOKING DOWN ON THE CROWN SHEETS OF THE MODELS.



MODELS JOINED READY FOR TESTS.

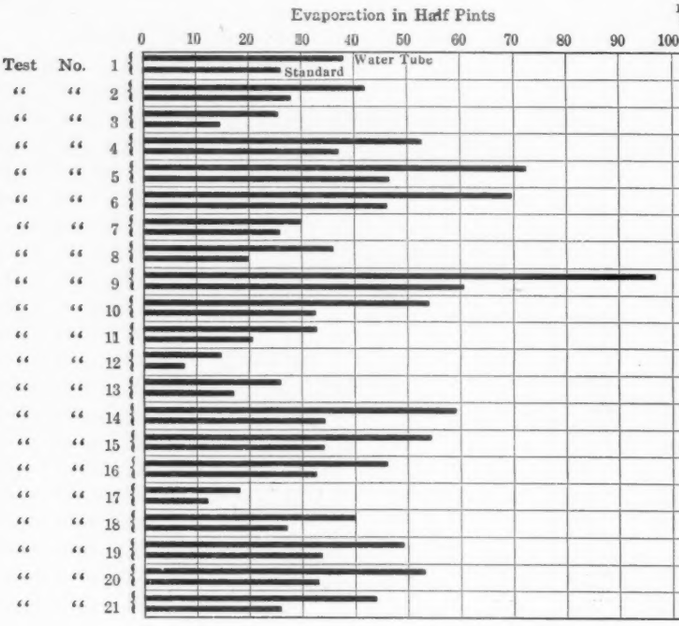


MODELS OF WATER TUBE AND STANDARD FIREBOXES.

Twenty-one tests, ranging from one to five hours each, were made on this model. In all cases the feed water was maintained at an initial temperature of 60 degs. and the amount of water used by each half of the model was accurately measured, being fed from same tank to it as required, a half pint at a time. All

tests were started with the same water level in each boiler, and since the firebox was common to both the results show clearly the merits of each design.

Tests under widely varying conditions were made, several being included in which the maximum evaporative capacity of the standard design of firebox was reached. These tests are shown graphically and in tabular form in an accompanying illustration. In this table the column headed "vapor" is the time in which the first vapor appeared in each half of the model; the column headed "steam" being the same observation when actual steam was formed in each half.



Difference, Per Cent of Standard	Vapor	Steam	Fuel	Burner	Arch	Time	Conditions
46 %	4 Min.	17 M.	Gas	Small	——	3 Hrs.	Preliminary
50 %	1 "	10 "	Gas	One Large	Low	2¼ "	Maximum Capacity of Burner
76 %	1¼ "	12¾ "	"	"	"	2 "	Maximum Capacity of Burner
42 %	4 "	13 "	Coal	——	"	2½ "	Poor Draft
55 %	1 "	12½ "	Gas	One Large	"	4 "	Maximum Capacity of Burner
51 %	1 "	11 "	Gas	"	"	4 "	" " "
15 %	1½ "	14 "	Gas	"	"	2 "	All Flues Plugged
80 %	1 "	11 "	"	"	"	2 "	" " Open
56 %	1 "	10 "	"	"	Standard	5 "	" " Plugged
66 %	1 "	10 "	"	"	No Arch	3 "	Maximum Capacity of Burner
58 %	1 "	12 "	"	"	Standard	2 "	" " "
93 %	1 "	25 "	"	Small	"	2 "	Combustion Rate, less than ¼
53 %	1 "	15 "	"	One Large	"	2 "	Maximum Capacity of Burner
73 %	¼ "	7 "	"	Double	"	2 "	Forced Burners to Maximum Capacity
60 %	¼ "	8 "	"	"	"	2 "	All Flues Plugged
41 %	1 "	10 "	Pine Sprigs & Needles	——	"	2 "	" " Open
50 %	1 "	12¾ "	Gas	Double	"	1 "	Fire so Smoky that 30% of Flues Plugged
48 %	1 "	12 "	"	Single	"	2 "	
43 %	1 "	8 "	"	"	"	2 "	
60 %	½ "	7 "	"	Double	"	2 "	
70 %	1 "	12 "	"	Single	"	2¾ "	Reduced Rate of Combustion

RESULTS OF EVAPORATION TESTS ON MODELS OF WATER TUBE AND STANDARD FIREBOXES.

The first six tests were made under different heat and draft conditions and show the gain in evaporation of from 42 to 76 per cent. in favor of the water tube firebox.

The seventh test was made with all of the barrel flues on the water tube side of the model blanked and shows a gain of 15 per cent. in favor of the water tube side, which means a gain of 15 per cent. for the water tube firebox alone against the full plain type of boiler.

In the eighth test these conditions were reversed and the plain type of firebox was operated in comparison with the whole boiler on the other side. This showed a difference of 80 per cent. in favor of the water tube side.

Tests 7 and 8 show the relative evaporations of the fireboxes alone.

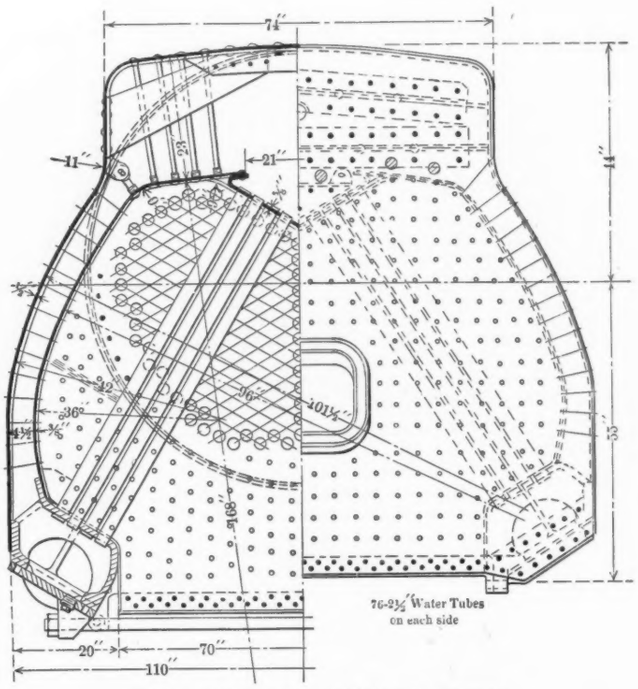
Test No. 12 shows the results with a reduced rate of combustion and gives the highest percentage of increase for the water tube firebox of any of the tests, showing that for a low rate of combustion this type of firebox is of unusual value.

Tests No. 14 and 15 were run at the maximum evaporative capacity of the plain firebox, which was found to be 34 half pints of water in two hours. It was not possible to force it beyond this point. The maximum evaporation of the water tube side, however, was not determined by any of the tests, as the means were not at hand to apply sufficient heat to determine it at this time.

Test No. 16 was run to show the effect of dirty and smoky fuel on the performance of the boiler.

Summing up the results of the tests as a whole we find that there was a total of 951½ half pints of water evaporated in 51½ hours from the water tube side of the model and 614 half pints in the same time from the other side, this being a gain of about 55 per cent. of the water evaporated in the ordinary type boiler in favor of the water tube firebox.

From the observations which it was possible to make by these tests it was discovered that with a low water level there was a decided tendency to bare the center of the crown sheet of the standard type of firebox under rapid evaporating conditions; whereas on the other half of the model the crown sheet was flooded even when the water level was low enough to show the top boiler tubes. This, of course, is due to the fact that the circulation about the firebox and up through the water tubes is so intense that the water is kept in circulation and the crown sheet flooded long after the danger point has been reached in the plain type. In the plain type of boiler the circulation was found to be very strong up the back tube sheet, up the back head and moderately strong up the side water legs. This was found to be practically reversed in the water tube type, the circulation, of course, being the strongest up the water tubes and was generally downward along the side and back legs, the current largely pass-



RIEGEL WATER TUBE LOCOMOTIVE FIREBOX.

ing forward from the top of the water tubes to the barrel of the boiler. It passed downward at the front end of the barrel back through the bottom row of flues and into the side water drum or hollow mud ring.

On inspecting the models at the end of the tests it was noticed that there was considerable scale deposits all over the surface of the firebox and on the flues of the plain type boiler, while these surfaces were practically clean in the water tube boiler, the circulation evidently having been strong enough to keep them scoured. The tests were made with water which scales very rapidly and results seem to uphold the contention that rapid circulation prevents scale formation.

In view of the fact that the water tubes in this model boiler were ¼ in. outside diameter, it not being possible to obtain a more exact size, and consequently were placed too close together, I believe that with a smaller number of tubes properly spaced, a boiler of this design and type would double the steaming capacity of the present type of plain firebox locomotive boiler, at the same time not occupying any more room on the engine. By thus doubling the capacity of the boiler it is evident that on account of the free steaming ability the rate of combustion could be very much reduced. This would be of advantage in two ways, one by reducing the amount of draft required and thus permitting an increased nozzle, and, secondly, the much more efficient combustion which it is possible to obtain at the lower rates.

SPECIFICATIONS FOR LEATHER BELTING.

TO THE EDITOR:

In an editorial on belting, page 151 of your April number, you emphasize the necessity for using only the best grade of belting in order to reduce the cost of maintenance to a minimum. Do you know of a belting specification which would insure securing a good quality of belting?

Chicago, Ill. MASTER MECHANIC.

The Santa Fe specifications for belting, as reproduced on page 456 of the December, 1906, issue, are very complete and belting bought under them has proved satisfactory. The best of specifications are, of course, useless unless rigidly enforced.

The United States Navy Department made a thorough investigation of this question and issued a specification, October 12, 1906, which is as follows:

"The belting shall be short lap. Must be of white leather of the very best quality, tanned with white or chestnut oak bark by the slow process, and no solutions, bark or wood extracts of any kind, or chemical processes shall be used, and the leather shall be thoroughly curried. Belting shall not crack open on the grain side when doubled strongly by hand, grain side out.

"No piece shall be more than 54 inches long, including laps; shall be cut lengthwise from the extreme end of butt, so as to exclude the shoulder, and shall be cut entirely from the center or back. No shoulder or belly pieces will be tolerated; all hides to be of the very best quality.

"Belting shall be waterproofed, if so specified, by an approved method; method shall be chemically neutral in character, containing neither tallow nor oil; the belting to have minimum stretch and a perfectly true run.

The weights shall be as follows for tanned belting not waterproofed; no loading of any description will be tolerated.

SINGLE BELTS.

Width	Weight per sq. ft.
1 to 2 inches	13 ounces.
2¼ to 4 inches	14 ounces.
4½ to 5½ inches	15 ounces.
6 inches and over	16 ounces.

DOUBLE BELTS.

1 to 2 inches	26 ounces.
2¼ to 4 inches	28 ounces.
4½ to 5½ inches	30 ounces.
6 inches and over	32 ounces.

LAPS.

Single belts.—Belts 6 inches wide or less, no laps to exceed 6 inches in length or to be less than 3½ inches in length; single belts wider than 6 inches, no laps will be more than 1 inch longer than the belt is wide.

Double belts.—No lap to exceed 5½ inches nor be less than 3½ inches in length.

CEMENT.

All laps to hold securely at every part, and when pulled apart the surfaces then exposed shall show no resinous, vitreous, oily, or watery condition. No filling strips of any kind will be tolerated. All laps and layers of leather must, in addition to being cemented, be copper riveted.

TESTS.

(a) Three strips cut lengthwise from any part of the same belt, including the lap, the inspectors may choose, 2 inches wide and 8 inches long and 2 inches between centers, and about 0.14 square inches in section at narrowest part, must stand an average ultimate tensile stress of 4,000 pounds per square inch of original area of test piece for all single belts and 3,600 pounds for all double belts. They should show an elongation of not more than 13.5 per cent. for single belts and not more than 12.5 per cent. for double belts when subjected to a stress of 2,250 pounds per square inch for one hour; elongation to be measured under stress.

(b) Note.—Under the strong magnifying glass the direction in which the leather has been cut can be determined by the direction of the follicles or hair pits, and if under this inspection the direction of the follicles is not clearly in a longitudinal direction, this defect will be cause for rejection of the length of belting containing this defect.

Commercial sizes of leather belting—that is, such sizes as would be found in the stock of any manufacturer—range from 1 inch upward, increasing by quarter inches as far as 4 inches, and then by half inches as far as 7 inches. Above this the increase is by inches.

Where belting is required for a special purpose, it would conduce toward obtaining the most suitable articles to inform the manufacturer of the nature of the work the belt is for, as well as the average horse-power that may be used to drive it and the speed of the belt in feet per minute.

THE HARRIMAN LINES AND PUBLIC OPINION.—Each general manager receives current issues of practically all newspapers and periodicals published in his territory. A competent person in his office, after careful scrutiny of editorial and other matters, tabulates and compiles a record showing the general attitude toward railways and other corporations of each publication. Twice a month each general manager telegraphs the director of maintenance and operation a brief fortnightly synopsis of public sentiment as reflected in the press, showing number of publications examined, percentage favorable, neutral, and antagonistic, quoting criticisms, complaints and expressions of special interest, and commenting upon the general trend of opinion as voiced from political and commercial centers. The Chicago office briefs and consolidates these reports for telegraphic transmission to New York. These reports are of great benefit in detecting causes of friction and enabling the application of prompt corrective measures. The regular reports are supplemented by special telegrams covering items or incidents of more than usual importance or significance. In addition, numerous newspaper clippings are currently forwarded by mail through the Chicago office.—*J. Kruttschnitt before the New York Railroad Club.*

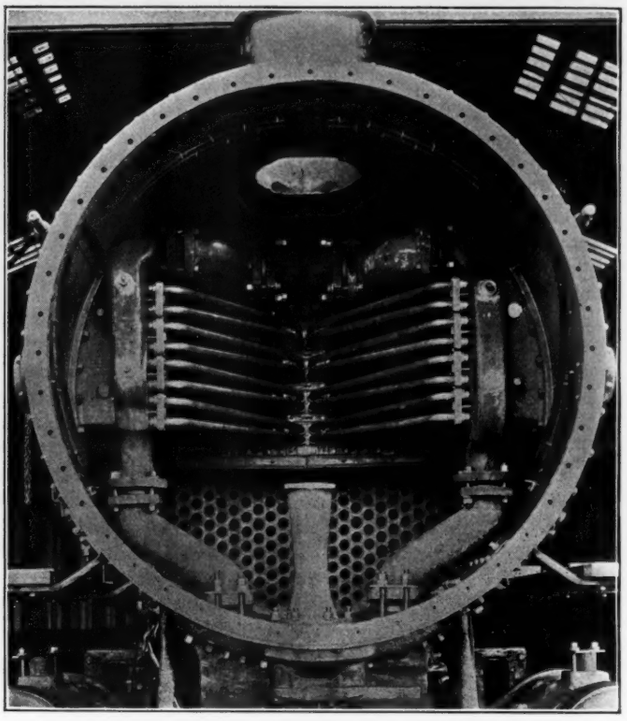
RAILROADS DOING GOOD BUSINESS.—The earning reports of twenty-five of the leading roads of the United States and Canada show a marked improvement over the same period last year as well as over the business done in March and April this year. These twenty-five roads show for the first week of May gross earnings $1,000,000 larger than for the corresponding period a year ago. This is an increase of 14 per cent. For the fiscal year 1909, or since July 1, 1908, to date, the combined earnings of these twenty-five roads have been slightly less than for the corresponding period last year, but the difference doubtless will be more than made up by July 1 next, as there is no doubt that business will continue to expand.—*Exchange.*

CONSOLIDATION LOCOMOTIVE WITH NEW DESIGN OF FIRE TUBE SUPERHEATER.

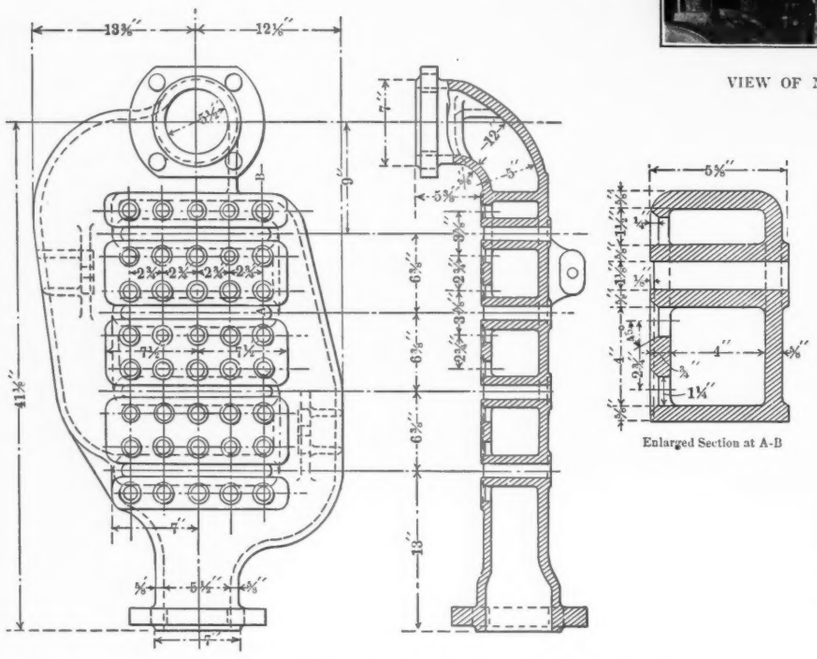
WABASH PITTSBURGH TERMINAL RAILWAY.

The Brooks Works of the American Locomotive Co. are delivering an order of ten consolidation locomotives to the Wabash Pittsburgh Terminal Railway, one of which is equipped with a new design of fire tube superheater. This locomotive carries 160 instead of 200 lbs. steam pressure and has 25 in. instead of 22 in. cylinders. In other respects, excepting of course the alterations in the boiler necessitated by the application of the superheater, it does not differ from the remainder of the order.

This design of superheater, the details of which are shown in the illustrations, is a distinct departure from the arrangement previously applied by locomotive builders in this country and overcomes most of the defects that service has shown the former arrangements to have. These defects for the fire tube superheaters have been, in general, the large number of steam joints to inspect and maintain, the difficulty of getting at the joints between the superheater pipes and the steam headers; the absence of an opportunity for taking care of the difference in expansion of the superheater pipes, thus leading directly to leaky joints; and to the liability of nuts and screw threads in the headers to corrosion.

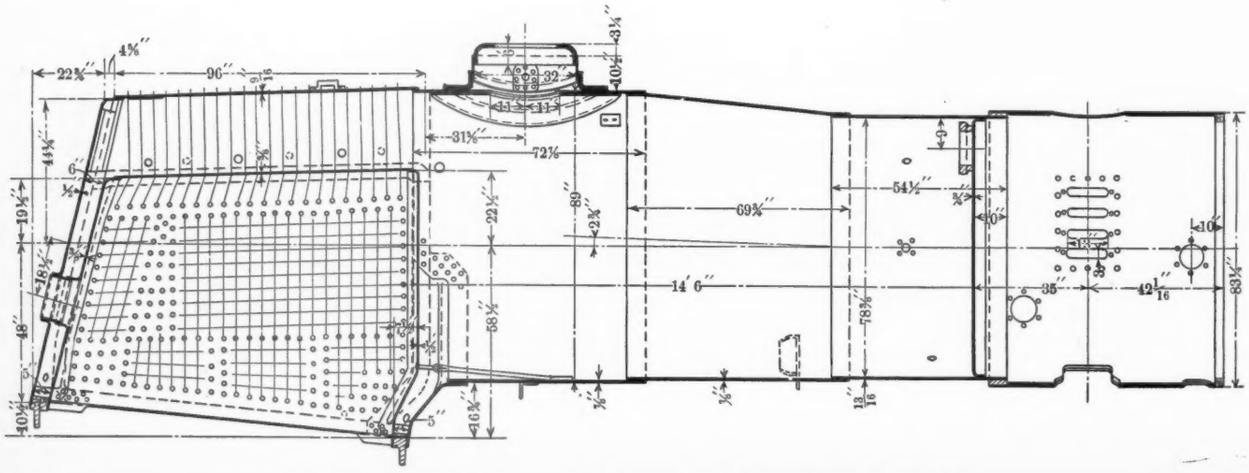


VIEW OF NEW SIDE HEADER FIRE TUBE SUPERHEATER.

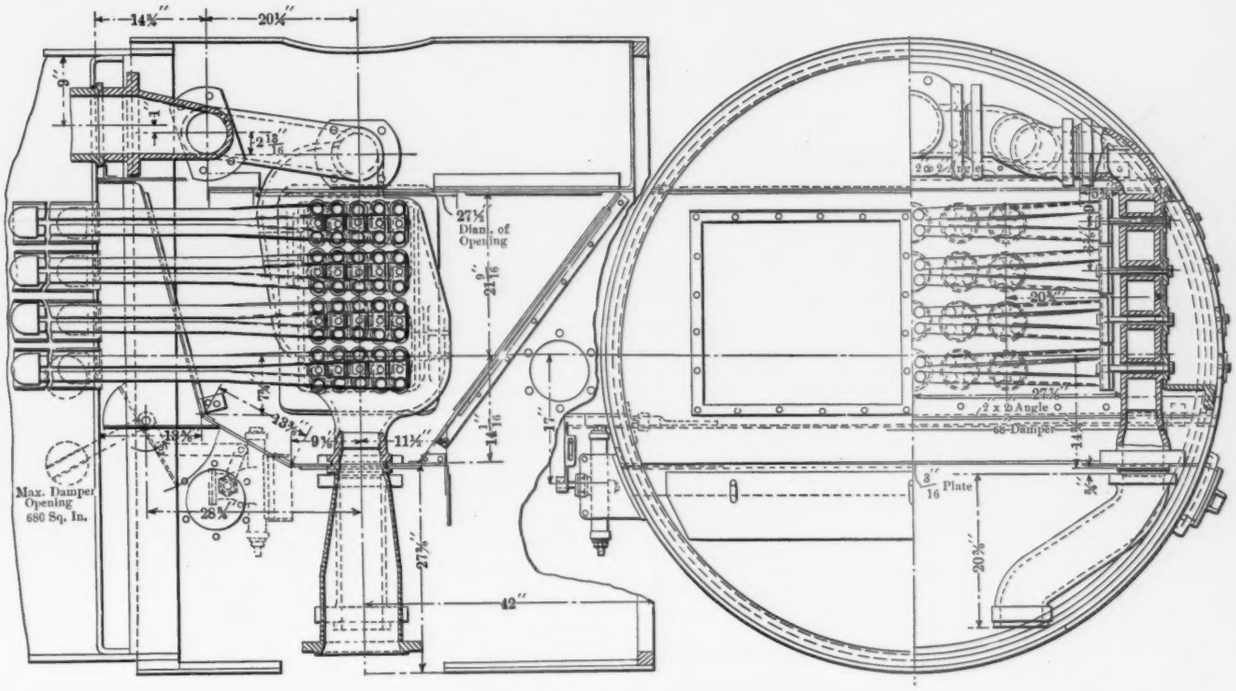


DETAILS OF SIDE HEADERS—NEW FIRE TUBE SUPERHEATER.

This new design has two steam headers located one on either side of the smokebox, each divided into saturated and superheated steam compartments, as is shown in the detailed drawing. A short curved pipe connects the saturated steam compartment of the header with the T head and the superheated steam comparement is connected by a short steam pipe to the cylinders. All the connections to the headers and steam pipes are made by cast iron ball joints. The headers are secured to a box casting bolted to the side of the smoke box, thus relieving the steam pipes and their connections from any strain due to the weight of the header. The large boiler tubes contain four seamless steel superheating pipes, 1½ in. outside diameter, arranged in pairs, the two pipes in each pair being connected at the back end by cast steel return bends. The superheating pipes on emerging from the boiler tubes are carried by an easy horizontal bend to



BOILER ON 2-8-0 TYPE LOCOMOTIVE TO WHICH NEW SUPERHEATER IS APPLILD.



SECTIONS OF BOILER IN WHICH THE SUPERHEATER IS FITTED.

their connection at the header. They are upset and machined to form a ball which is ground into the socket of the header. The two pipes forming an element are held to their seats by means of a double clamp with a bolt in the center between the pipes. These bolts pass through cored holes in the header and have nuts on the back, where they are protected from the smokebox gases. Covered openings are provided in the smokebox to give access to these bolts from the outside. There are no soft joints of copper or composition employed anywhere in the design.

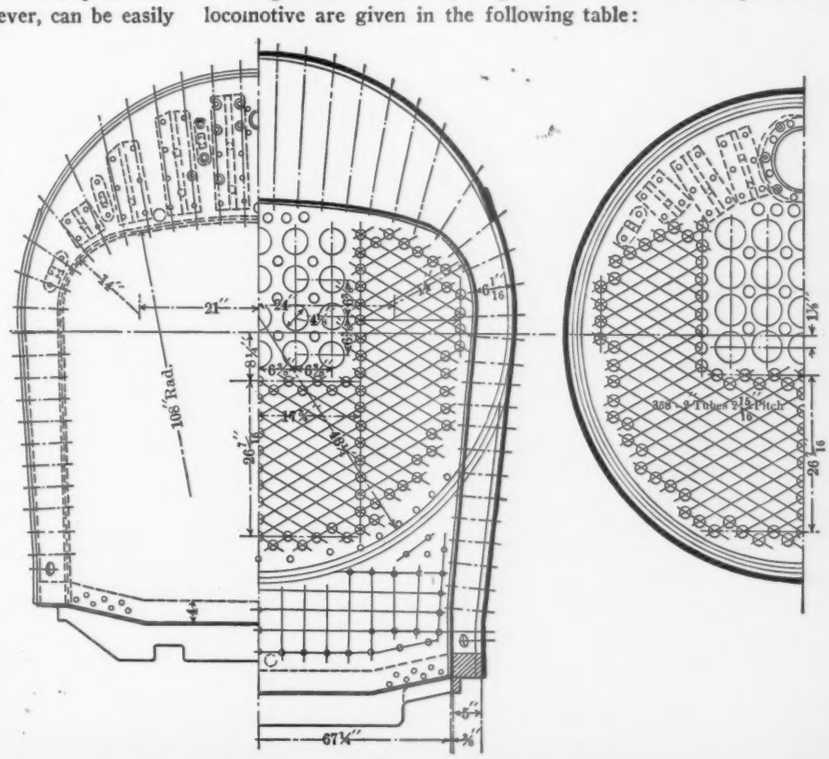
The design shown herewith is arranged for a superheat of from 100 to 125 degs. and hence requires but one loop in each superheating element. The same scheme, however, can be easily arranged to give higher degrees of superheat by having a double loop, or a four-pipe superheating element, in each superheating tube and a reduced number of connections to the header.

The passage of the gases through the 5¾ in. tubes and around the superheating pipes is controlled by a damper, which is automatically operated by a steam cylinder on the outside of the front end. This cylinder is directly connected to the steam chest and is operated by the pressure therein. When the throttle is open the pressure in this cylinder opens the damper, but when the steam is shut off a counterweight closes it. In arrangements for giving a higher degree of superheat it is possible to easily arrange this automatic damper, so that it can be partially or wholly closed from the cab when the locomotive is operating, in case too high a temperature is being attained.

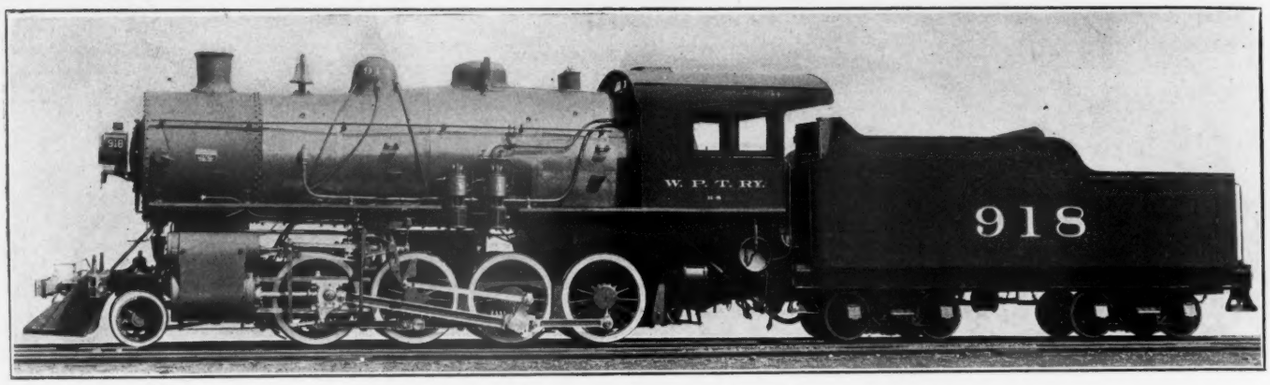
The boiler in which this superheater is applied is shown in the illustrations, and has a total heating surface of 3,283 sq. ft. The superheater has 374 sq. ft. of heating surface, bearing a ratio of 8.78 to the total. There are 20.6 sq. ft. of superheating surface to each cubic foot of cylinder volume, which is slightly lower than has been customary, because of the lower degree of superheat that has to be attained. The boiler has 14 ft. 6 in. tubes and the superheater elements reach within about 32 in. of the back tube sheet.

The other nine locomotives in this order have the same cylinders as are used on the superheater locomotive, their diameter, however, being reduced by a bushing 1½ in. thick, to 22 in. They are designed to carry 200 lbs. steam pressure, but by the removal of the bushing can readily be changed to superheater engines with reduced pressure if it is desirable. The locomotive shown in the photograph is not equipped with the superheater.

The general dimensions, weights and ratios of the superheater locomotive are given in the following table:



SECTIONAL ELEVATIONS OF BOILER WITH NEW DESIGN OF SUPERHEATER.



CONSOLIDATION TYPE LOCOMOTIVE—WABASH-PITTSBURGH TERMINAL.

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	46,900 lbs.
Weight in working order	236,000 lbs.
Weight on drivers	207,000 lbs.
Weight on leading truck	29,000 lbs.
Weight of engine and tender in working order	390,000 lbs.
Wheel base, driving	15 ft. 9 in.
Wheel base, total	25 ft.
Wheel base, engine and tender	59 ft. 11 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.41
Total weight ÷ tractive effort	5.03
Tractive effort x diam. drivers ÷ heating surface	825.00
Total heating surface ÷ grate area	65.00
Firebox heating surface ÷ total heating surface, %	5.80
Weight on drivers ÷ total heating surface	63.00
Total weight ÷ total heating surface	71.70
Volume both cylinders, cu. ft.	18.20
Total heating surface ÷ vol. cylinders	181.00
Grate area ÷ vol. cylinders	2.78

CYLINDERS.

Kind	Simple
Diameter and stroke	25 x 32 in.

VALVES.

Kind	Piston
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	0 in.
Lead, constant	3/16 in.

WHEELS.

Driving, diameter over tires	58 in.
Driving, thickness of tires	4 in.
Driving journals, diameter and length	10 x 12 in.
Engine truck wheels, diameter	33½ in.
Engine truck, journals	6½ x 12 in.

BOILER.

Style	E. W. T.
Working pressure	160 lbs.
Outside diameter of first ring	80 in.
Firebox, length and width	109 x 68 in.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	5 in.
Tubes, number firetubes	358
Tubes, number superheater firetubes	20
Tubes, diameter firetubes	2 in.
Tubes, diameter superheater	5¼ in.
Tubes, length	14 ft. 6 in.
Heating surface, tubes	3,093 sq. ft.
Heating surface, firebox	190 sq. ft.
Heating surface, total	3,283 sq. ft.
Superheater heating surface	374 sq. ft.
Grate area	50.5 sq. ft.
Smokestack, diameter	19 in.
Smokestack, height above rail	15 ft. 4 in.

TENDER.

Tank	Water bottom
Frame	13 and 10 in. chan.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	8,000 gals.
Coal capacity	14 tons

PERCENTAGE OF POWER BRAKES ON TRAINS.

The Interstate Commerce Commission held a hearing in Washington on May 5th, concerning an increase in the minimum percentage of power brakes on railroad trains. A large delegation from the Chicago General Managers' Association attended the hearing with C. A. Seley, mechanical engineer of the Rock Island Lines as chairman; he also acted as chairman of meetings in Washington to arrange for the reports and arguments on the part of the railroads. W. B. Scott, assistant director of maintenance and operation, Harriman Lines, presented an argument from the standpoint of the transportation department. The legal argument was participated in by most of the counsel present, including representatives from the Rock Island Lines, New York Central Lines, Louisville & Nashville and the Southern Railway. Mr. Hamilton, traveling air brake instructor of the Santa Fe, presented an argument for the air brake department. The argument of the motive power and car department was prepared by a committee consisting of R. Quayle, superintendent motive power, Chicago & Northwestern; J. F. Devoy, mechanical engineer of the Chicago, Milwaukee & St. Paul Ry., and F. F. Gaines, superintendent motive power of the Central of Georgia. It was read by Mr. Gaines and is as follows:

The original "Safety Appliance Act," passed by Congress in 1893, went into effect August 1, 1900, and required that a sufficient proportion of each train be equipped with power brakes, operated by the engineer on the locomotive, to control its speed without the need of hand brakes. The amendment of March, 1903, provided that after September 1, 1903, all trains should have a minimum of 50 per cent. of the cars with power brakes. By an order of the Commission, effective August 1, 1906, the minimum percentage of power braked cars to be used in any train was increased from 50 to 75 per cent. Let us consider what it would mean in practice if the law was changed to require a still higher percentage of cars equipped with air-brakes.

The law effective August 1, 1900, did not designate what percentage of the vehicles in each train should have power brakes, but did say that there should be sufficient power brakes in the train to control its speed, without the use of hand brakes. This was a very wise provision, and this law, to-day, applies better to the mountainous roads than any subsequent legislation or rules. It was comparatively easy for the railroad to do this as it was simply a matter of money expenditure.

When the amendment was passed in 1903, requiring that all trains should have a minimum of 50 per cent. of the cars with power brakes, it was a little more difficult from the standpoint of operation, but still it was complied with by the railroads and was not impracticable from an operating standpoint. When, however, the rule was passed making the percentage of air-braked cars in every train 75 per cent. it was found to be more difficult. The first 25 or 50 per cent. was easy, the next 25 per cent., making a total of 75 per cent., was considerably harder, and everything above 75 per cent. will tax the railroads from the operating standpoint to such an extent that not only will they be greatly inconvenienced by attempting to do it, but the traveling public and shippers will also be inconvenienced; the former because of trains being off schedule by having to make repairs on air brakes in the train, and by having to set out cars with defective brakes, should the number of working brakes be less than that prescribed by the Commission; the shippers would be inconvenienced because of the cars containing their commodities (whether perishable or otherwise) being set out to have such

repairs made as would be necessary to maintain the percentage required by law.

The railroads, to-day, particularly the larger ones, where they haul a large number of cars, have great difficulty at times in making up their trains so as to conform to the present law of 75 per cent., and should this be increased, the hardship will increase in geometrical ratio. Especially is this true on the branch lines, where a train starts out with one or two cars and comes to a station and picks up another car, and so on, until it gets down to the end of the branch line; if one of these cars should be defective (perhaps one loaded with grain and another with stock) it would have to remain until employees were sent out to repair it.

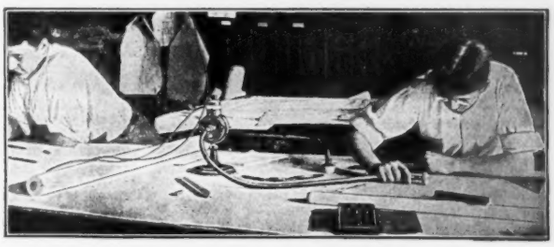
It may not be known to the Commission, but it is nevertheless a fact that it is not an infrequent occurrence on branch lines to pick up empty air-brake cars, solely for the purpose of maintaining the legal percentage of air brakes in working order, that we may be able to take through to destination some other load of freight upon which the air brake may be inoperative. Therefore, in such a case, as just noted, if the percentage was increased, the railroad companies would probably have to carry a lot of empty cars in both directions, in order to comply with the law; this, notwithstanding the fact that it is upon these very branch lines that the traffic is most safe, on account of the infrequency of train service.

It is generally agreed that in heavy service the percentage of inoperative air-brake cars in each train will average about 15 per cent., such cars being inoperative from all manner of defects of brake rigging, as well as from the many defects pertaining strictly to the air-brake apparatus. In this service these cars come into terminals with regular frequency, at which terminals there are competent air-brake men and testing plants; hence, when we consider that our efficiency in this particular service and under these favorable conditions is but 85 per cent. on an average, we can readily conceive that if we are to be confronted with a legal minimum higher than 75 per cent., such minimum is more than likely to interfere with the service and the prompt movement of freight.

All railroads have what are known as way freight trains, or local trains, which do a great deal of picking up; the through trains often set out cars that are defective for various reasons, including air brakes, and these cars have to be picked up and brought to terminals for repairs; as the law does not make any discrimination as to the kind of service, the railroad company operating these local trains is obliged by law to have just the same percentage in them as they have in through and more important trains; inasmuch as it has been the practice of railroad companies to have the local trains do all the picking up of damaged and defective cars, and having been taxed to the limit to keep within the present requirements of the law, it would be impracticable for them to do much better without increasing the delay to merchandise.

FLEXIBLE SHAFT APPLICATIONS OF INTEREST TO THE RAILROADS.

The flexible shaft used in connection with the following specialties is made by the Coates Clipper Manufacturing Company of Worcester, Mass. It consists of hardened steel units; one end of each unit is the shape of a spheroid which has been trimmed so that a transverse section is square while a section taken longitudinally through two of the diagonally opposite corners corresponds at the end to part of an ellipse. This fits into a squared socket in the preceding unit. The shaft is thus not only flexible but is very strong. The units are held together by a pin which does not, however, transmit any power. They are made in a number of sizes for transmitting from one-tenth to one hundred horse power. The shaft runs inside of a steel spring, which is covered with leather, and is equally efficient whether run forward or backward.

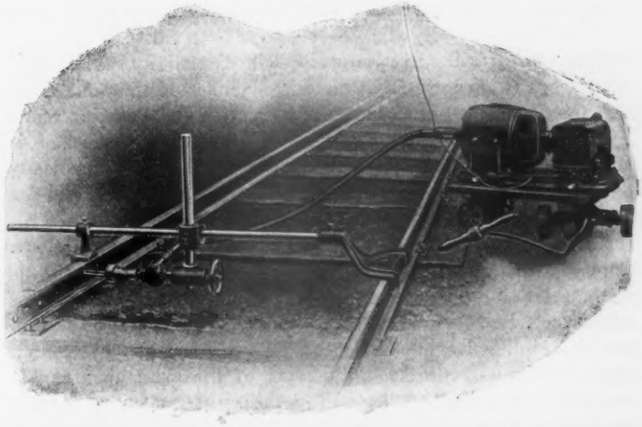


A HANDY DEVICE FOR ERASING IN THE DRAFTING ROOM.

SHOWING CONSTRUCTION OF FLEXIBLE SHAFT UNITS.

One of the illustrations shows a portable outfit for drilling rails; it may also be used for various purposes in the repair shops and yards. The motor and controller are mounted on a truck and power is transmitted to the drill press through the flexible shaft. The drill is attached to a fork or clamp which fits over the rails. This is much more easily adjusted than an "old man" and can quickly be removed. By means of a lever which throws different gears into mesh any one of three speeds may be obtained. The motor and the flexible shaft operate at a

FLEXIBLE SHAFT USED IN CONNECTION WITH CAR WINDOW CLEANING DEVICE.



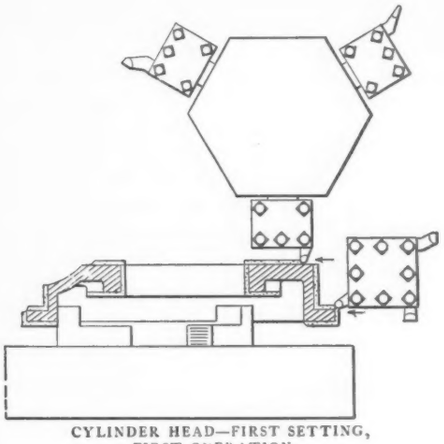
PORTABLE DRILLING APPARATUS SUITABLE FOR TRACK WORK, REPAIR YARDS AND REPAIR SHOP.

constant speed. An outfit of this kind has been used successfully and been found very efficient for driving cylinder boring machines.

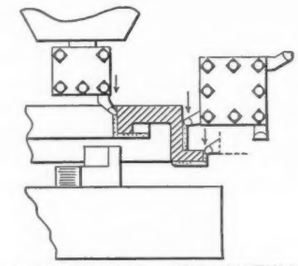
The flexible shaft in connection with a small motor may be used to advantage in a number of ways in the drafting room. An ink or a pencil eraser revolving at high speed does much better and neater work than by hand. A rubber cleaning brush may be used for cleaning drawings; a circular sand paper disk for sharpening pencils or a circular crocus for sharpening the needle points of the instruments or of drawing pencils or for removing rust from the instruments. One of the illustrations shows an application for cleaning car windows.

Cylinder Head.—This head is not of the locomotive type, but is similar to it in some respects and also to other classes of work that are common in railroad shops. The cylinder fit is 28 in. in diameter; the head may be machined in two settings and three operations, as shown, in one hour and thirty minutes.

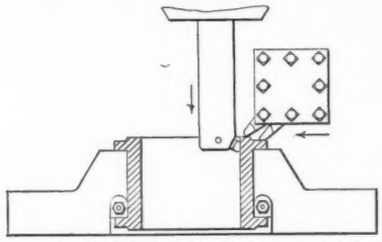
Piston Head.—At the first chucking of the piston head the back face, outside diameter, taper and grooves are machined as shown by the two sketches. The head is then chucked a second time and the front face and the recess for the retaining nut are machined; the balance of the outside diameter which could not be turned at the first chucking is also finished. The time required for a 20 in. head of this type varies from 1½ to 1¾ hours.



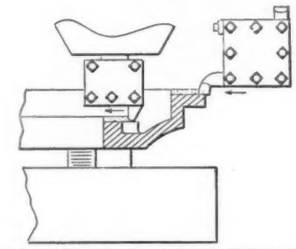
CYLINDER HEAD—FIRST SETTING, FIRST OPERATION.



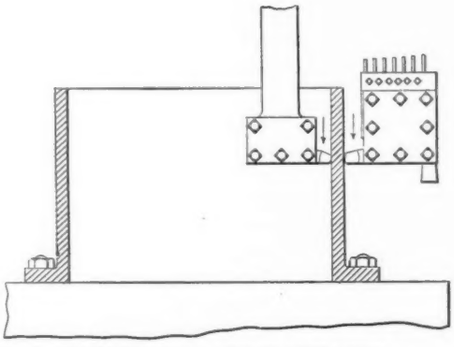
CYLINDER HEAD—FIRST SETTING, SECOND OPERATION.



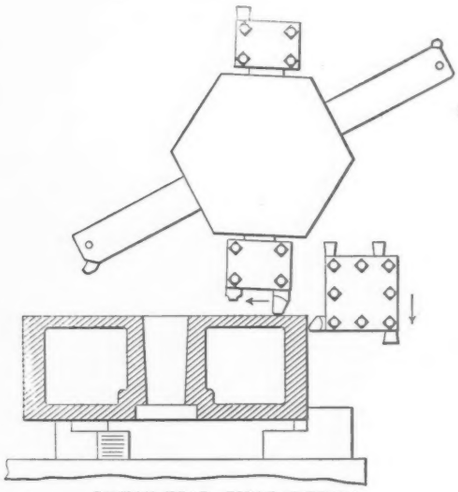
ROD BRASS HELD IN SPECIAL CHUCK JAWS.



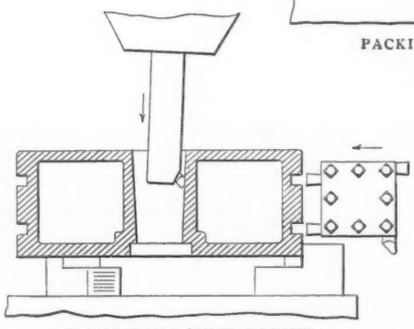
CYLINDER HEAD—SECOND SETTING, FINAL OPERATION.



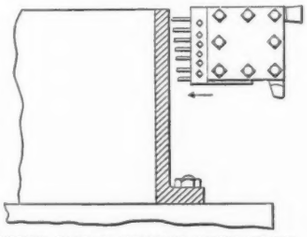
PACKING RINGS—FIRST OPERATION.



PISTON HEAD—FIRST SETTING, FIRST OPERATION.



PISTON HEAD—FIRST SETTING, SECOND OPERATION.



PACKING RINGS—SECOND OPERATION.

THE VERTICAL TURRET LATHE IN RAILROAD SHOPS.

That the vertical turret lathe is well adapted for use in railroad shops is apparent from the large number of these machines that have been installed in such shops during the past few years. Some idea of the amount and range of work for which it is suited may be gained from the number of these lathes (designated as vertical rapid production lathes) specified for use in the Scranton shops of the Delaware, Lackawanna & Western Railroad, and the work for which they are intended, as shown in Mr. Pomeroy's article in the April issue.

A machine of this type was described on page 408 of the October, 1907, issue. It has a main turret head on the cross-rail, having a full universal movement, both vertical and horizontal. The side head is entirely independent of the main head and is carried on a rail at 90 degrees to the cross-rail. The accompanying sketches illustrate its adaptability to railroad shop work and also show how simple are its tool requirements.

Rod Brasses.—These may be held to the best advantage by special chuck jaws, as shown; the jaws have true surfaces for the flanges to rest upon—taper gibs are used to draw the brasses to a seat. They are bored and faced at the same time. Brasses for seven-inch pins may be bored and faced on both sides in two settings in fifteen minutes.

Packing Rings.—In the making of plain packing rings the tub casting is bolted to the table and is bored and turned at the same time; the rigidity of the two tools is greater than is possible with a straddle bar and on that account a tub of greater length may be machined without necessitating a reduction in the feed and speed used. In cutting off, a series of parting tools are held in a simple holder and seven rings are parted at one cut—the top tool has a slight lead over the second one, and so on down to the last tool, in order that all the tools will not break through at the same time. From 80 to 100 rings, 20 in. in diameter and ⅝ in. square, may be machined per day, according to the quality of iron used.

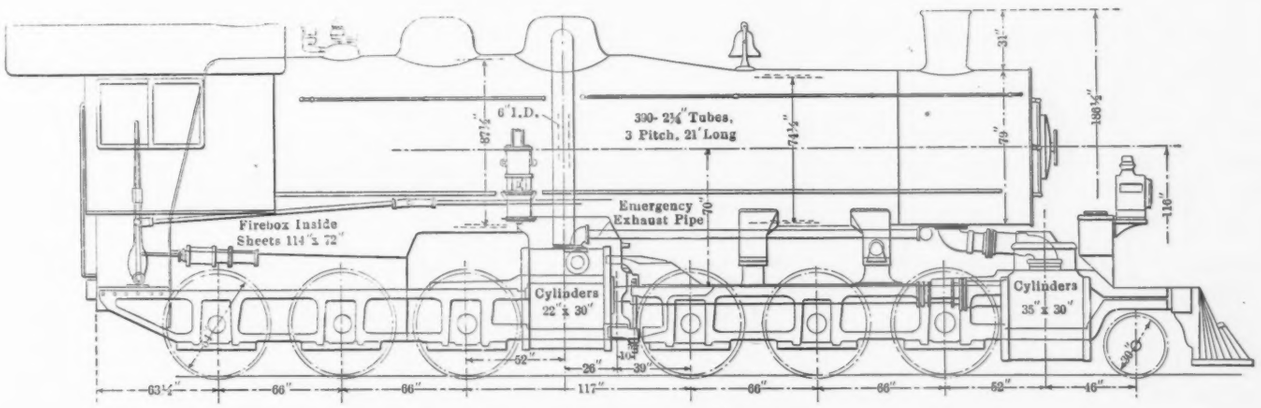
We are indebted for this data to The Bullard Machine Tool Company, Bridgeport, Conn., on whose machines this work is performed.

MALLET ARTICULATED COMPOUND LOCOMOTIVES 2-6-6-0 TYPE.

VIRGINIAN RAILWAY.

In addition to the twelve Mikado type locomotives built by the Baldwin Locomotive Works, which are illustrated and described elsewhere in this issue, the Virginian Railway is also receiving four of the articulated compound type from the Richmond Works of the American Locomotive Company. The designs and specifications for all these locomotives were prepared under the direction of R. P. C. Sanderson, superintendent of motive power of the railway. In working order it is estimated that the articulated locomotives will have a total weight of 330,000 lbs., of which 312,000 is carried on driving wheels. The tractive effort, working compound, is 70,800 lbs. The Mellin intercepting valve is applied which will permit the tractive effort being increased 20 per cent. by working both sets of cylinders as simple engines, a separate exhaust pipe being provided from the high pressure cylinders to the front end for this purpose.

A two-wheel leading truck has been specified, making these engines of the 2-6-6-0 type, this being the first example of this wheel arrangement to be put in service in this country. A fully illustrated and detailed description of these locomotives will appear in the July number of this journal and but a brief mention of a few of the most prominent features will be made at this time.



A radial stayed extended wagon top type of boiler, 76 in. in diameter at the front ring, is used. It contains 390 2¼ in. tubes, 21 ft. long, and has a total heating surface of 5,065.9 sq. ft., of which 4,842 sq. ft. is in the tubes. The firebox is 114 in. long and 72 in. wide and has a grate area of 57 sq. ft. The mud ring is 5 in. in width at the sides and back and 6 in. wide in front. The location of the boiler, relative to the frames and cylinders, is shown in the outline diagram above.

The design of the frames and cylinders is much the same as has been used by these builders on locomotives for the Baltimore & Ohio and Erie Railroads. The application of the front truck made necessary some changes in the exhaust pipe from the low pressure cylinders and introduces two sliding supports on the front group of frames instead of one. The high pressure cylinders have piston valves and the low pressure Allen-ported slide valves. The front and rear systems of frames are equalized together by a vertical bolt, the load through the bolt to the rear section being transmitted through a coil spring. A flexible support at this point is required because of the three-point applications of weights to the front group of wheels.

The cylinders are 22 and 35 in. in diameter, with a stroke of 30 in. The wheels are 54 in. outside diameter and the rigid wheel base is 11 ft., the total wheel base being 39 ft. 11 in. The boiler carries 200 lbs. of steam pressure and soft coal is used for fuel.

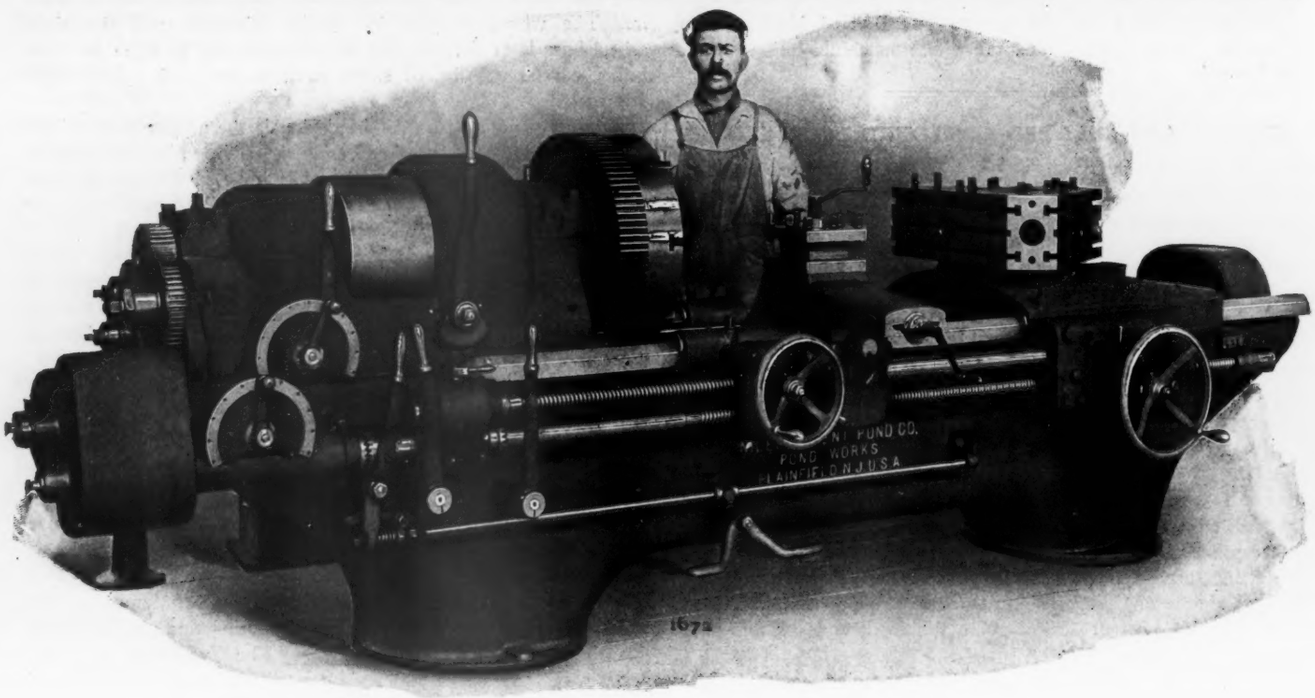
An interesting feature of the design is the arrangement of the draw gear between the engine and tender, in which the locomotive draw bar pin is horizontal and is inserted through the side of the foot plate. This construction will be illustrated when the locomotive is more fully described in the next issue.

The locomotives are designed for use as pushers with heavy coal trains on the Clark's Gap grade on this railway, which is 2.07 per cent., 14 miles in length. Later it is intended to use them in similar service on the White Thorne grade, which is .6 per cent., 10 miles in length.

RAILWAY STOREKEEPERS' CONVENTION.—The sixth annual convention of the Railway Storekeepers' Association was held in the Auditorium Hotel, Chicago, on May 17, 18 and 19. Committee reports and individual papers were presented on store department organization; locomotive tools and supplies; classification of material; pricing requisitions before purchasing and several papers on treatment and inspection of lumber. Dr. Von Schrenck, supervisor of timber preservation on the Rock Island, gave an illustrated paper on "The Treatment of Lumber," which attracted much interested attention. Details of comparative costs of ties and lumber during the past twenty years on the New York Central Lines west of Buffalo were presented. Topical discussions were given on the subjects of, "Prompt and safe transportation of company material in other than supply cars" and "Minimum stock, how influenced by prompt purchase and delivery." The reports, papers and discussions were of a very valuable nature throughout.

MASTER MECHANICS' SPECIAL TRAIN FROM CHICAGO.—The Pennsylvania Railroad will run a special train from Chicago to Atlantic City for the accommodation of the members of the mechanical associations. This train will leave Chicago at 5:30 P. M. June 14, and arrive in Atlantic City at 5:00 P. M. June 15. The fare will be $26 for the round trip. Tickets will be on sale June 1 and have a 30-day return limit with stop-over privileges. Reservations can be secured at the office of the city ticket agent, 248 South Clark street, Chicago.

PENNSYLVANIA ELECTRIC LOCOMOTIVES.—The Westinghouse Electric and Manufacturing Company has received orders for twenty-four electric locomotives for service in the New York tunnels of the Pennsylvania Railroad. Each locomotive will consist of two units permanently coupled together and the wheel arrangement of the complete machine will be of the 4-4-4-4 type. These engines will be larger and more powerful than any electric locomotives heretofore built, each having a capacity of about 4,000 horse power.



TURRET LATHE ADAPTED FOR EITHER PIN OR FACE PLATE WORK.

A NEW TURRET LATHE FOR PIN WORK.

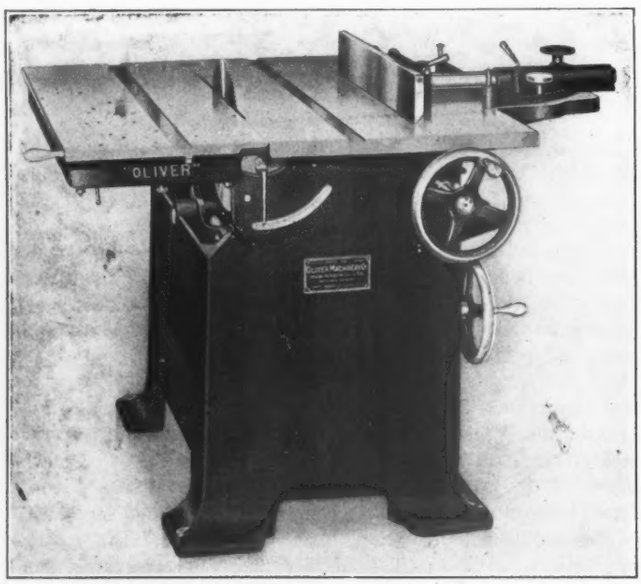
A turret lathe that will handle bar work up to six inches is a necessity in a large locomotive repair shop. Crosshead wrist pins, knuckle joint pins, the smaller sizes of crank pins, large washers, bushings, etc., can be turned in much less time than required on an engine lathe.

A combination turret lathe, adapted for either bar or face plate work, may be used to advantage in both the larger and smaller size repair shops. The illustration shows a machine of this kind built by the Pond Works of the Niles-Bement-Pond Company. It is driven by an eight-inch belt, but, if desired, may be furnished with a motor drive, the motor being mounted above the headstock. With the belt drive fifteen spindle speeds are provided, including those furnished by the countershaft. The automatic turret traverse and the revolving mechanism make the machine easy to operate.

The lathe is designed for handling work up to 28 in. in diameter; the swing over the carriage arms is 26 in. and over the carriage 24½ in. The face plate is equipped with a 24 in., three-jaw, universal chuck with special jaws for bar work. Other types of jaws may be furnished to suit special classes of work. The carriage is so designed that it passes under the chuck, permitting the faces of the turret to be run close to the chuck. This is a most desirable feature as it reduces the overhang of the boring bars and facing heads to a minimum. Six changes of independent feed are provided for both the carriage and the turret, each having a separate lead screw, so that the work may be turned while boring is being done at different rates of feed.

The turret has a travel of five feet. It has a rapid power traverse on the bed and rotates automatically at any desired point of traverse. These movements are controlled by one lever. Each turret face has an independent feed stop. The wide faces of the turret make it possible to rigidly secure the heaviest tools.

The lathe may be built with either a 6 or a 4½-in. hole through the spindle. Its design and weight are such that it is adapted for a heavy class of work.



UNIVERSAL SAW BENCH SHOWING RIPPING FENCE IN ITS NATURAL POSITION.

UNIVERSAL SAW BENCH.

The universal saw bench, illustrated herewith, will rip any width up to 26 in., cut off any width up to 36 in., make any angular cut to 45 degrees, and by the use of a dado head groove any width up to 4½ in. It is fitted with self-locking and self-oiling devices and has quick and micrometer adjustments for locating the ripping fence and tilting the table. An endless belt transmits the power through a tightening device to pulleys on the two saw arbors upon the yoke, which may be revolved by a worm and worm gear mechanism so as to place either saw in operation.

The table may be tilted by turning the lower handwheel, which operates a worm, worm-wheel, arm and lever. A dial, placed so that it may be read easily while the table is being tilted, is provided showing accurately the degree of pitch. The table is divided into two parts, a stationary table 24x44 in. and a sliding table 17 x 44 in. Each table is furnished with sliding gauges graduated from 30 to 150 degrees; strips of steel are provided to fill the gauge slots when not in use. The sliding table is graduated from 30 to 150 degrees; a miter cut-off gauge is used in connection with this scale. The frame carrying the sliding table may be set back by loosening a cam lever at each end, permitting the use of dado or cutter heads up to 4½ in. in width.

The ripping fence is adjustable to rip 26 in. wide on the stationary table; it also operates on the sliding table for bevel sawing; it tilts from 90 to 45 degrees and has an adjustment of 10 in. without changing the pins. The fence is provided with an adjustment of 10 in. from the front edge of the table.

The arbor yoke carrying the cross-cut and rip saw is made in

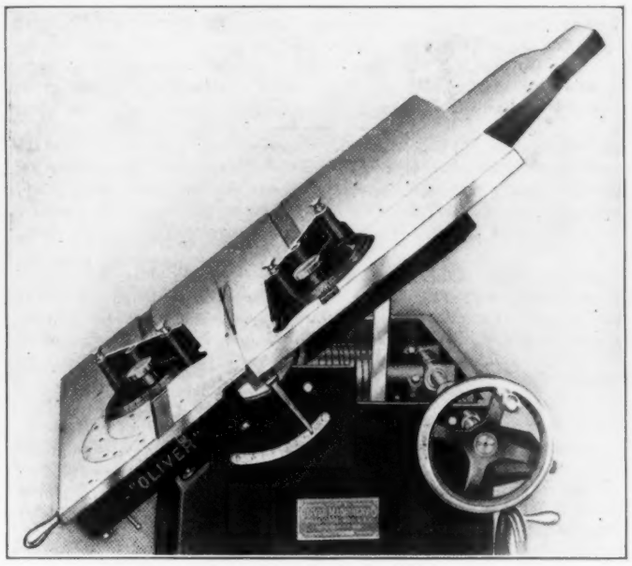
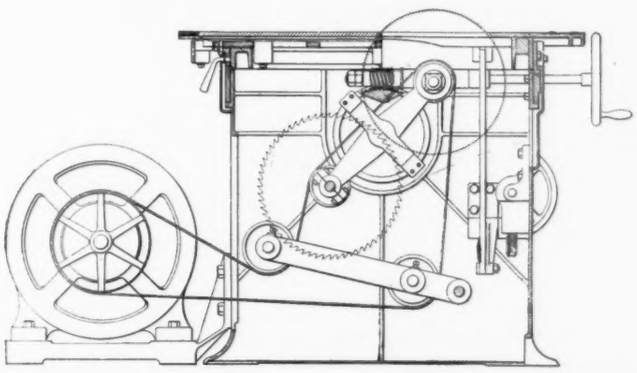


TABLE TILTED TO 45 DEGREES.

one casting and is 6½ in. in diameter where it passes through the yoke hole in the frame. It is locked in position by a threaded split cap bearing 9¼ in. in diameter. The other end of the yoke is supported by a substantial, removable, steady plug. The arbor bearings are long and self-oiling; the arbor pulleys are grooved and are 4½ in. in diameter, 5½ in. face. The arbors



ARRANGEMENT OF MOTOR DRIVE TO UNIVERSAL SAW BENCH.

are of crucible steel and one of them is arranged to receive dado cutters. A special device is provided for taking up all end play in the arbor.

The machine weighs 2,100, is designated as No. 60, and is manufactured by the "Oliver" Machinery Company, Grand Rapids, Mich. It may be arranged to drive either from a countershaft or motor; the motor may be mounted on a specially arranged bracket attached to the base of the machine, or may be set on the floor.

SAFETY OF PASSENGER TRAVEL.—During the calendar year of 1908, of the 141,659,543 passengers carried on the Pennsylvania Railroad, not one was killed as a result of an accident to a train. The total number of passengers injured in train accidents numbered only 102 as compared to 452 in 1907.

PERSONALS.

F. E. Fox, master mechanic of the Denver & Rio Grande R. R. at Denver, Colo., has resigned.

A. Shields, master mechanic of the Canadian Northern Ry., has been appointed also master mechanic of the Duluth, Rainy Lake & Winnipeg Ry.

Willard R. Collins has been appointed the purchasing agent of the Erie R. R., with office at New York, succeeding E. T. Campbell, assigned to other duties.

H. Carrick, assistant division master mechanic of the Oregon Short Line at Pocatello, has been appointed master mechanic of the Montana division, with office at Pocatello.

A. H. Gairns, division master mechanic of the Oregon Short Line, with office at Pocatello, Idaho, has been appointed master mechanic of the Idaho division only, with office at Pocatello.

A. R. Kipp, formerly superintendent of motive power of the Wisconsin Central Ry., has been appointed mechanical superintendent of the Chicago division of the Soo Line.

J. H. Davis, assistant electrical engineer of the Baltimore & Ohio R. R., has been appointed the electrical engineer, with office at Baltimore, Md., succeeding L. T. Gibbs, deceased.

W. M. Netherland, general storekeeper of the Southern Railway, has been appointed also the general storekeeper of the St. Louis-Louisville Lines, with office at Washington, D. C.

J. B. Finley has been appointed the general storekeeper of the Harriman Lines in Mexico and Southern Arizona, with office at Empalme, Sonora, Mex., succeeding G. V. Green, resigned.

George Ross, district foreman of the Oregon Short Line at Salt Lake City, Utah, has been appointed master mechanic of the Utah division, with office at Salt Lake City, and the office of district foreman has been abolished.

J. J. Ellis, for a number of years in the motive power and mechanical department of the Chicago, St. Paul, Minneapolis & Omaha Ry., and until the early part of this year superintendent of motive power, has retired from railway service.

T. A. Foque has been appointed general mechanical superintendent of the Minneapolis, St. Paul and Sault Ste. Marie Ry. This road has recently leased the Wisconsin Central Ry. and will operate it as part of its own system to be known as the Chicago division.

CATALOGS.

AIR CYLINDER LUBRICATOR.—The Detroit Lubricator Company is issuing a small folder describing its sight-feed air cylinder lubricator. These lubricators were described in the columns of this paper, November, 1908, and since that time have been subject to a number of improvements, which are fully described in this leaflet.

VALUABLE GRAPHITE PRODUCTS.—What might be called a pocket edition general catalogue is being issued by the Joseph Dixon Crucible Company, Jersey City, N. J. This little pamphlet, which is of commercial envelope size, lists the principal products of this company, giving brief descriptions and prices, and will no doubt prove to be of value to any one who may have an occasion to use or specify graphite in any of its forms.

DIRECT-CURRENT GENERATORS.—Engine-type direct-current generators, designed for general lighting and power service, are illustrated and described in detail in Bulletin No. 1059, being isued by the Allis-Chalmers Company, Milwaukee, Wis. These machines are suitable for direct connection to steam, gas or oil engines and have many features of construction which have given them a well-established reputation for reliability.

RATCHET WRENCHES.—The Lowell Wrench Co., Worcester, Mass., is issuing a leaflet giving illustrations, brief description and price list of reversible ratchet wrenches in a number of different styles.

THREE TOOLS THAT SAVE.—The Cleveland Twist Drill Company, Cleveland, Ohio, is issuing a small folder calling attention to the catalogues which it has prepared descriptive of "Peerless" high-speed reamers, "Perfect" double-tang sockets and "Paradox" adjustable reamers. This leaflet briefly mentions the prominent advantages of each tool.

DISTRIBUTING TRANSFORMERS.—Circular No. 1502, issued by the Westinghouse Electric & Mfg. Company, contains much valuable information on alternating-current distribution, covering transformers, lightning arresters, insulators, etc. Considerable space is devoted to underground and overhead construction, applicable in congested and scattered districts. Information is also given on potential regulating systems. The circular contains 52 pages of information of value to any one concerned with the distribution of power by alternating-current lines.

TRIBUTE TO THE GALENA SIGNAL OILS.—The address of Attorney John G. Milburn in the suit of the Government vs. the Standard Oil Company, in which he gave a deserved tribute to Gen. Chas. Miller, is being issued in small pamphlet form by the Galena Signal Oil Company, Franklin, Pa. He stated that no basis exists for any charge against the Standard Oil Company in the achievements of General Miller with the Galena Signal Oil Company, and that, on the contrary, he is entitled to much credit for his methods.

TIRE TURNING.—The May issue of "Progress Reporter," Niles-Bement-Pond Company, 111 Broadway, New York, is devoted to the subject of tire turning. It gives a number of excellent illustrations of wheel lathes in operation, both for driving and car wheels, and recounts some of the results that are being obtained in regular daily service on the various machines. The three tools that are necessary for proper turning of driving and car wheel tires are illustrated by photographs and full-dimensioned line drawings.

LOCOMOTIVE REDUCING VALVES AND AIR PUMP GOVERNORS.—The Mason Regulator Company, Boston, Mass., is issuing a small catalogue which fully describes the construction, operation and proper maintenance of the Mason locomotive reducing valves and air pump governors. Sectional illustrations with numbered parts make the descriptive matter and directions for cleaning very clear. These reducing valves are standard on the leading railway systems of this continent, as well as in Great Britain and Europe and wherever else steam heating of trains has been introduced.

FAIRBANKS-MORSE & Co., Wabash Ave. and Eldredge Place, Chicago, are issuing a 640-page general catalogue, No. 60, which illustrates, briefly describes and gives tables of full dimensions and prices of the products handled by them. The products of this company are too extensive and diversified to be given individual mention in this place, and in general include machinery and tools of the following classes: Electrical machinery, which takes in both motors and generators for direct or alternating current; gas and gasoline engines and suction producers, including gas engines of all sizes and types; mining machinery, including air compressors, hoists, full electrical equipment, rock drills, etc.; pumping machinery for either high pressure or irrigation; steam engines and boilers of many types; scales, which, of course, include practically every known type of weighing machine; wind mills, pipe fittings, hose, etc., and railway machinery and supplies, which include coaling stations, hand cars, motor cars, track and shop supplies of all kinds, gasoline locomotives, water stations, turntable machinery, etc. The catalogue is bound in cloth, well printed and is profusely illustrated.

CAR HEATING AND LIGHTING.—A 9 x 12-in. catalogue, arranged in loose-leaf form, with a special post binder and containing over 200 pages printed on heavy coated paper, is being issued by the Safety Car Heating & Lighting Company, 2 Rector St., New York. The contents of this catalogue makes clear the thorough manner in which this company is meeting the demand in the car lighting and heating field. Among the devices which have been given special attention are the axle dynamo electric lighting system and the thermo-jet system for heating, which have during the past few years deserved and been given special recognition by railroad managements. The axle light system has been perfected after sixteen years' experience, and in its present arrangement presents all that makes for efficiency, reliability and economy. The service that has been given by the new thermo-jet system of car heating has been most pleasing to this company, and this system, which is a form of heating by direct steam and provides absolute regulation of the temperature at all times, is fully described in the catalogue. The Pintsch gas mantle lamp is, of course, fully shown. This form of lighting has been received with great favor, and large numbers of the old flat-flame equipment are being altered to these mantle lamps, with great satisfaction and economy. The catalogue is fully illustrated, finely printed and attractively arranged.

NOTES.

HOMESTEAD VALVE MFG. COMPANY.—Woodward Wright & Co., of New Orleans, will represent the above company in that district and will carry a complete stock of Homestead valves.

T. H. SYMINGTON COMPANY.—William A. Garrett, president of the Seaboard Air Line, has resigned and on Nov. 1 will become vice-president of the above company at Baltimore, Md.

CROCKER-WHEELER COMPANY.—Edmund Lang has been placed in charge of the repair shops of the above company at Ampere, N. J. Mr. Lang for the past five years has held an executive position with the Wheeler Condenser & Engineering Company.

ROGERS JOURNAL PACKING COMPANY.—Willis C. Squire, 307 Western Union Building, Chicago, has been appointed general sales agent of the above company, which is now manufacturing a much-improved journal packing, using the original Rogers steel wool in combination with high-grade cotton waste mixed with sponge.

SAFETY CAR HEATING & LIGHTING COMPANY.—In order to enable the largest steamers to enter New York harbor at night, the government has ordered a large number of Pintsch gas buoys for indicating the channel. There are 2,200 buoys of this type now in service throughout the world, a clear indication of the reliability of Pintsch gas equipment.

FLANNERY BOLT COMPANY.—This company reports that locomotives equipped largely with Tate flexible staybolts, are now running, which have been in service for over three years with no staybolt breakage, with no cracking of side sheets and no engine time loss due to staybolt repairs. They will be glad to give the locations of such engines to any one interested.

SLACK MANUFACTURING COMPANY.—W. W. Slack, president, and H. K. Parkman, secretary of Gilman & Son, Inc., Springfield, Vt., and G. C. Parker, sales manager of the Wm. J. Smith Company, New Haven, Conn., have formed a partnership for the purpose of manufacturing and selling abrasive metal cutters, under the name of Slack Manufacturing Company, Springfield, Vt., all parties to retain their present positions with their respective companies.

L. E. WATERMAN COMPANY.—The business of this company in Canada has increased to such an extent that it became necessary to build a Canadian factory, which was recently completed and opened with proper ceremonies on the twenty-fifth anniversary of the company. It is located at St. Lambert, near Montreal, and contains 31,000 sq. ft. of floor space. It is of concrete construction and fitted throughout with the most modern machinery for making fountain pens.

WALTER B. SNOW, publicity engineer, 170 Summer street, Boston, announces the association with his staff of Carl S. Dow, S.B., engineering department, Harvard University, late publicity manager B. F. Sturtevant Co., and formerly in charge of instruction and text book departments, American School of Correspondence. Mr. Dow brings to the organization a diversified experience which will add materially to the value of the service rendered in all lines of technical publicity.

FALLS HOLLOW STAYBOLT COMPANY.—A large order for Falls hollow staybolt iron has recently been received from one of the largest railway systems in England. This railway wishes to test this iron, with a view of adopting it as a standard. Several new agencies have been established by this company during the past month. Among these are Brydges Engineering & Supply Company, 249 Notre Dame Ave., Winnipeg, Can., who will cover the territory in Canada west of Lake Superior. Mussens, Ltd., 299 St. James St., Montreal, Can., have been allotted the territory in Canada east of Lake Superior. H. J. Skelton & Co., Royal London House, Finsbury Square, London, E. C., has been made the representative for the British Isles and India.

CARDWELL FRICTION DRAFT GEAR.—The Union Draft Gear Company, of Chicago, has recently been organized, with the following officers: James R. Cardwell, president and general manager; Charles A. Jennings, vice-president; John D. Ristine, secretary and assistant treasurer; C. H. Tobias, treasurer and assistant secretary. The company has a paid-up capital of $2,000,000 and has bought the patents and business of the Cardwell Manufacturing Company. It will continue the manufacture and sale of the friction draft gear which was started by that company in the latter part of 1904. The evolution of draft gear has shown that a gear for simply lengthening the stop when cars are bumped or jerked will not suffice, but that the gear must absorb the blow. Reports of drop tests recently made of Cardwell friction gear show that a blow of 1,660,500 lbs. is reduced to 115,312 lbs. in passing through it, and a blow of 1,037,812 lbs. is reduced to 15,375 lbs. It is the failure of draft gears thus to absorb buffing shocks that adds so greatly to the repair bills. The Cardwell gear is designed to reduce by one-half the speed of the blow or impact in transmitting it to the car. This reduces the force of the blow to one-fourth. This fourth is resisted by springs on a floating spring rod, actuated by the operation of twelve transversely acting friction faces which continue the work of absorption, so that the shock to the car is enormously reduced. The gear is easily applied, is open to inspection and may be readily repaired. The Union Draft Gear Company starts in business with a large number of contracts and orders on hand. Its principal business will be the manufacture of the Cardwell friction draft gear, but it will also sell spring draft gears where they are desired.

PRESIDENT'S ADDRESS—MASTER MECHANICS' ASSOCIATION

H. H. VAUGHAN

In 1868 six master mechanics attending the Master Car Builders' Convention at Dayton decided to call a general meeting at Cleveland to organize an association of the master mechanics of the United States and Canada. At that meeting, which was held later on in the same year, fifty were present, representing many of the most important lines of railways in the country, and a constitution was adopted with the following preamble:

"We, the undersigned railway master mechanics, believe that the interests of the companies by whom we are employed may be advanced by the organization of an association which shall enable us to exchange information upon the many important questions connected with our business."

These words outlined the object with which the new society began its career, adopting as its purpose the discussion of the best methods of construction and operation of the locomotive at a time when it had just emerged from the experimental stage and was assuming a permanent and fairly uniform design. It had already taken its place in the world as the most powerful and economical engine of transportation, but few even who were connected with it in those days could have foreseen the development it was to undergo or the extent to which it would render possible the cheapening and extension of the transportation facilities of the world, the chief factor in the wonderful change that has taken place in the relations of nations, the distribution of food supplies and the growth of manufactures, cities and continents.

The association so quietly started was well founded. It had chosen for its aim a work that was needed, and as the railways of the country grew, it grew with them, until now, forty-one years later, we have a membership of nine hundred and sixty-one (961), representing every railway in the United States and Canada, and a large number of those in foreign countries. It has been unique in its devotion to the locomotive and its problems alone, but its object has proved worthy of its attention, and we are to-day confronted with problems just as important as those which our predecessors considered, none the less vital to us because they are broader in scope and because financial considerations are now more closely connected with those which are purely technical.

I have always been deeply interested in the history of this association; I have been a great admirer of the work that it has done, and I am going to take this opportunity to speak to you of the success it has obtained, the methods it has used, and the opportunities that lie before it for the future.

It is impossible to review in detail the work which has been accomplished; the mass of information contained in our proceedings is too great for individual reference. To even touch on the more important subjects would necessarily result in a mere catalogue. Figures are but a poor way of illustrating results, but in the forty-one years of our proceedings three hundred and fifty-one (351) reports of committees, sixty (60) individual papers and one hundred and fifteen (115) topical subjects have been presented and discussed. Of these reports and discussions it may be stated that one hundred and twenty-six (126) contain information of special interest at the present time, while two hundred and eighty-three (283) are of specific value, either in whole or in part. While this classification is to a certain extent a matter of opinion, it shows most decidedly the general excellence of the work which this association has done. It has investigated almost every conceivable subject connected with the locomotive, its construction, operation and maintenance, developing, criticising and discussing it as it progressed from the little sixteen-inch eight-wheel locomotive of the sixties to the magnificent freight and passenger equipment of the present day. To say that the wonderful development that has taken place is entirely owing to the work of our association would be an exaggeration. Apart, however, from the facts determined in our reports, the improvements they have suggested, and the practice they have introduced, our meetings have year by year been attended by the men engaged in carrying on and advancing this work. They have presented their own views in our discussions, they have heard the views of others, and, whether speakers or listeners, have returned home from our conventions with their opinions modified, new ideas conceived and their experience broadened. With that renewed energy and interest in their work which invariably results from communication with other workers in the same field, they have put into practice suggestions which have been advanced and by their daily work have together built up that mass of knowledge and experience that has resulted in the production of the American locomotive of to-day. In such ways, as well as by the exchange of information, our association has succeeded in its object in being of benefit to the railways by whom our members are employed.

Our work has not been limited, however, to the exchange of information, but from the very beginning our committees have done far more than obtain and report existing facts or give the opinion they have formed as a result of their inquiries. This has been an important and valuable portion of their work, and our history shows that in the large majority of cases it has been done well. The answers received to the letters of inquiry have frequently indicated a great divergence of opinion or a lack of proper knowledge, while our later experience has justified the committee's decision. Their reports have presented carefully thought out and correct conclusions, which have through their evidence of thorough investigation and the standing of the members of the committees, been widely accepted and of valuable assistance in establishing advanced practice. A development of their work to which I wish to call your attention has not, I believe, been generally awarded the credit it deserved, yet it has been the source of the greatest influence exerted by our association, and of the importance of its service to the railways. I refer to the investigation of the scientific principles underlying the questions assigned to our committees, the tests and experiments they have carried out when necessary to determine additional data, and the correct and practical conclusions they have deduced. As a result their work stands to-day as the basis of most of our scientific knowledge of the locomotive, the engineering principles on which it is designed, and the reasons for the methods by which it is operated.

I do not mean that we have to look to our committees for all the knowledge that is available on the theoretical mechanics of the locomotive, or for such researches as those on the properties of steam, the strength of materials, or the chemistry of combustion. That has been the work of the mathematician or physicist, and its value in solving the practical problems of engineering is limited by the vast number of factors which enter into actual working conditions. Our work on the other hand, has been the observation and interpretation of results in a scientific manner, and through being carried on by practical men, who have established the relation between the facts they ascertained, and the theoretical principles underlying them, has been sound in its basis, and rendered general in its application.

What further can we do to increase our usefulness and develop into still more important fields of work? I feel that in making

suggestions I am recording my own sins of omission, and yet when a man endeavors to seriously consider such a question, ideas occur to him that previously lay dormant or unthought of, and this must be my excuse for recommending now what I have not done. Our opportunities are somewhat different from those of our great sister society, the Master Car Builders' Association. We have no such business relationships to regulate between one road and another as those involved in the interchange of equipment. The possibilities of establishing additional standards that would be extensively used are few, and indeed it is very doubtful whether standards are of much value for the locomotives of an entire country. We must consequently ask ourselves whether we are obtaining all classes of information that are of possible value, and whether our committee reports, individual papers and topical discussions could be advantageously supplemented by any other activities.

We are face to face with several changes in the development of our motive power and the department having charge of it. The steam locomotive, that has been supreme for so many years, is finding its superiority questioned by a new invention, the electric locomotive. The small railway with its individual methods is being absorbed into large systems, and superintending and recording the work under the charge of our members is becoming more difficult. The growth of the large mechanical departments has made it impossible and in fact undesirable for their heads to retain the same touch with minor mechanical and operating details that they formerly had to, and has increased the importance of the financial and business questions they should control as compared to those of a mere technical nature. Unless this association and its members concern themselves seriously with these new and larger problems, there is danger of their work being undertaken by others in place of by ourselves.

The articulated locomotive has widened the field of the steam locomotive and enabled it to compete on more favorable terms with its younger and more powerful rival. We should be informed of every development in this line, the results and the experiences that are being obtained and the reduction in the cost of transportation that is being realized. We should also, I feel, know more of electric operation, so that as motive power officers we may be better informed as to its advantages and disadvantages, and may be in position to assist in deciding on the proper system to employ.

The advice of men experienced in motive power matters is needed by the railways in making decisions on this question. To be of value it must be based on a thorough understanding of the subject and a familiarity with its difficulties. I would urge your giving earnest attention to this important subject, which thus far has received too little consideration by the men who best understand railway motive power conditions.

Systems of organization are changing with the changes in our railways and new methods are being introduced for watching results. We should compare experience as to the efficiency of various types of organizations, obtain more information as to the best forms of records, statements that are actually found useful and successful in practical service; comparisons that can be made on a reasonable basis and are interchangeable.

I believe we should endeavor to pay more attention to the commercial side of our work than we have done in the past. Excellent as our work has been, it has with few exceptions investigated the technical rather than the business problems of the locomotive.

We certainly do not want to decrease our attention to technical matters, but could we not with advantage to our members and to the railways take more interest in, and exchange information with each other more fully on factors connected with the cost of operation?

It is true that some years ago a standard postcard performance sheet was adopted and for a time was extensively exchanged, but it fell into disuse, and yet a properly prepared performance sheet, giving figures useful and possible of comparison, would, I feel sure, be of considerable value and interest to us all. The benefits of a membership in this association would be increased by information as to each other's cost of engine house expenses and supplies, of repairs and fuel consumption, the percentage of power in shops and out of service, and a number of other figures that have to be continually watched. Knowledge of the results obtained by others would assist us all in gaging our own performance, in more easily locating the branches in which we are deficient, and in encouraging all to a higher uniformity of accomplishment.

In short, without in any way reducing the interest we have in locomotive engineering, we must take up in a far more business-like and serious way the financial problems connected with the operation of the locomotive department, the form of organization that will give the best results, the commercial aspect of the work of a motive power official in conducting his department as though he were manager of a large business enterprise.

Take as an instance of comparing costs the operation of our repair shops. We manage the largest collection of factories in the world devoted to one substantially uniform product, the repairing of locomotives, and our total expenditure for this item alone amounts to about eighty million dollars per year. Each and all have the keenest interest in knowing whether our methods are the best and our costs among the lowest. A few years ago comparisons would have elicited little, but some statements of performances which were exceptionally worthy of imitation; to-day, with the progress that has been made in shop engineering, there is no reason why properly trained observers should not record time studies containing the necessary data to prepare intelligent and valuable statements about one operation after another that is performed on substantially the same parts in hundreds of shops from the Atlantic to the Pacific. Such work is possible and it has already been performed in several shops by experienced engineers. If carried on by a properly organized bureau under our auspices, it should be of the greatest value not only to the railways of this country as a whole, but to our members individually. By comparing operation by operation, their results with those of other roads, and by analyzing their methods and available machinery, they would be enabled to improve the one or justify their expenditure for additions to the other. This is but one of many questions connected with the operation of our mechanical department which will occur to you, on which some systematic interchange of information would be of material assistance.

What I wish most strongly to impress on you is that while still carrying on the technical work that has been so splendidly successful, we should pay more attention to the business problems under our control in which we can be of such mutual service.

Our methods of obtaining information might also, I consider, be supplemented to advantage by effecting closer relations with the various railway clubs. The circular letter has been a practical failure in obtaining general information, and I feel sure that the railway clubs would welcome reference to them of certain subjects for their opinion, especially those on which the experience of the men actually in touch with the work is required. They have a large membership, representing every section of the country and every class of men engaged in locomotive work. On many subjects their views would be of far greater value than those obtained in answer to circular letters, especially on questions similar to those suggested for topical discussion.

A valuable practice which obtained in the past, but which has been discontinued in recent years, was the appointment of a committee to report on the advancement in locomotive practice during the year. There are numerous small improvements devised in railway shops which would be collected by a committee gaining its information from the railway clubs. These improvements, while not of sufficient importance in themselves to justify a report or paper, are of considerable value in our successful operation, and presented by a committee would have sufficient indorsement to insure their being carefully considered.

Co-operation with the railway clubs would also relieve the association of the discussion of details of minor importance which have occupied so much time in the past. Such discussion is necessary, and, in fact, of the greatest value, but it more properly belongs to local societies where local conditions are understood and where it can be carried on just as efficiently and satisfactorily as when occupying the time of a national association.

Our association could, I believe, also be of considerable value

with reference to the various legal questions that are arising in connection with locomotive construction and operation, by co-operation with the American Railway Association. We could provide a systematized organization for obtaining the opinions of the railways with the proper representation for each section of the country and a meeting at which important questions could be discussed.

Any development in this direction must, however, come at their request, and we can simply indicate our willingness to undertake any work in which we can be of use.

The present system of holding the conventions of the Master Mechanics' and Master Car Builders' associations in two separate weeks prevents many from attending one or the other. The consequence is the attendance is largely divided, and unfortunately so, as the majority of the members of either association are equally interested in the other. There are two remedies: the first, to hold the two conventions in one week; the second, to unite the two associations. When this was last proposed by the late Mr. Pulaski Leed in 1898, our executive committee was instructed to confer with that of the Master Car Builders' Association, but, although a report was made to the succeeding convention, suggesting that both conventions should be held during the same week, nothing was done.

It is a reflection on the business ability of our mechanical departments to continue an arrangement that necessitates a man being away from his work for practically two weeks at the meetings of important associations, which he should, for his own sake, and that of the railway employing him, attend and take part in.

There is to-day no valid reason for maintaining two separate mechanical railway associations. All the officers and members of the executive committee of the Master Car Builders' Association, with the exception of two, seventy-five per cent. of the members of the standing committees, and seventy per cent. of the members of the special committees, hold joint department titles.

These figures demonstrate most clearly the amalgamation that has taken place between the car and locomotive departments on our railways. They justify the statement that the time has arrived not for the absorption of one of our associations by the other, but for their uniting into one society, call it, if you please, the American Railway Mechanical Association, which would consider both car and locomotive matters. Such a step is demanded by the spirit of the times, to conserve the forces of our railway officers and economize their time. It is one of the most important questions we have to deal with, and I would impress on you the necessity for action being taken to remedy the present conditions.

The help of our association has been requested by the National Conservation Commission, and it has been informed that our resources would be at their command either for purposes of investigation or to ascertain the recommendations of our members in any respects in which we could be of service to them. A committee was also appointed which could co-operate with them if required, or with any of their committees, but so far this has proven unnecessary, and our position has been simply that of exhibiting our willingness to perform any work that might assist this important movement. We have, however, our own share to carry of the duty of the nation to posterity. The railways are one of the largest consumers of coal, and in most cases peculiarly indifferent to the economy with which it is used. About two hundred millions of tons are annually burned in locomotives alone, and we do not therefore need to ask in what direction we can be of service in assisting this commission. Our work is before us. We should individually, and as an association, use every means in our power to impress on our railways the importance of this expenditure, one of the largest we are responsible for. The reduction in the present rate of consumption that it is our duty to make will not only lead to an immense saving in expense, but will assist materially in the conservation of the natural resources of the country.

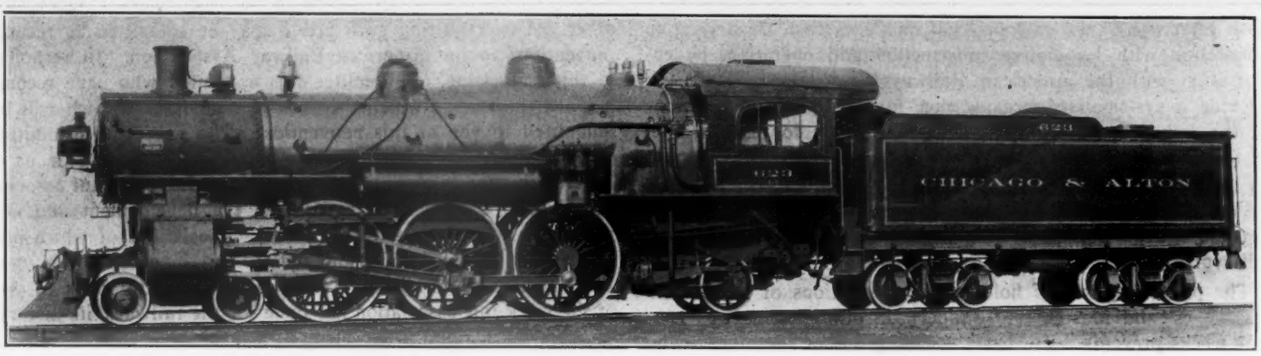
At our last convention several of our members were asked by members of the American Railway Association to introduce an alteration in our constitution whereby subjects involving legal, transportation, permanent way or traffic questions or for any other reason requiring such action may be submitted as recommendations to the American Railway Association. In response to this suggestion, a committee was appointed who have recommended the change which they consider advisable, which will be submitted to you at this convention. The executive committee has carefully considered the amendment and indorse it as a progressive step in the orderly grouping of the important associations which are all working toward the development and advancement of American railway work, associations of which our own is one of the largest and oldest. An innovation, however, this amendment certainly is, and it has led me to speak to you of the work this association has done for the railways, its history, its achievements and its problems.

PEAT AS A FUEL IN THIS COUNTRY.—The statement is made by Federal experts that millions of dollars' worth of fuel lies undeveloped in the swamps and bogs of the country. Its value, on a basis of $3 a ton, roughly guessed at by experts of the Geological Survey, who have been studying the peat deposits for some time, is more than thirty-eight billion dollars—more money than is represented in all the property, stock, implements and buildings owned by the farmers of the United States. With the coal supply being used at a tremendous rate, peat is expected to become a most important auxiliary fuel and one that will prolong the life of the coal itself. An important fact which leads the experts to believe that peat will soon come into quite general use in certain parts of the country is that it is as a rule found in quantities in regions far removed from the coal fields, so far that the cost of transporting the coal amounts to several times the cost of the fuel itself at the mines. The states containing the greatest amount of peat are the eastern Dakotas, Minnesota, Wisconsin, Michigan, northern Iowa, Illinois, Indiana, Ohio, New York, the New England States, New Jersey, portions of Virginia, North and South Carolina, Georgia and Florida.

CONSERVATION OF NATURAL RESOURCES.—The recovery of heat units in our domestic fireplaces and furnaces is far less than the recovery of heat from coal burned under our best boilers, when measured as power generated in our steam engines. And the waste in our kitchens and at our tables involves a greater national loss than the waste in our coal mines. In the one case the people at large are making no effort to minimize it, while every technical man of repute is putting his best endeavors into devising means of getting the highest efficiency out of nature's forces, with a view to turn nature's resources indirectly to the greatest good for the greatest number.—*James Douglass at the New Haven meeting of the Am. Inst. of Mining Engineers.*

CARE OF BELTING.—The care of belting should be entirely taken out of the hands of the men who are running the various belt-driven machines, and belts should be systematically retightened at regular intervals, with belt-clamps fitted with spring-balances, each belt having the tightening strain carefully figured in advance. Belting should also be cleaned at regular intervals, and should be softened with a small amount of belt-dressing which is needed to keep it in perfect condition. A laborer can be quickly trained to tighten and care for all the belts in the shop during the noon hours and on Saturday afternoons, and at other times when the shop is not running.—*Fred W. Taylor before the A. S. M. E.*

A GENERAL FREIGHT CAR POOL.—The Harriman freight car pool is not unlike those of the Pennsylvania and of the New York Central. When the principle is extended to the pooling of car pools, the car efficiency and traffic of American railways will be appreciably increased. The same methods that brought about a reduction of 54,000,000 miles movement of empty cars on the Harriman Lines in two years after their inauguration would make a proportionate reduction of 477,000,000 miles annually on the railroads of the United States.—*J. Kruttschnitt before the New York Railroad Club.*



PACIFIC TYPE LOCOMOTIVE WITH PILLOID VALVE GEAR—CHICAGO AND ALTON RAILROAD.

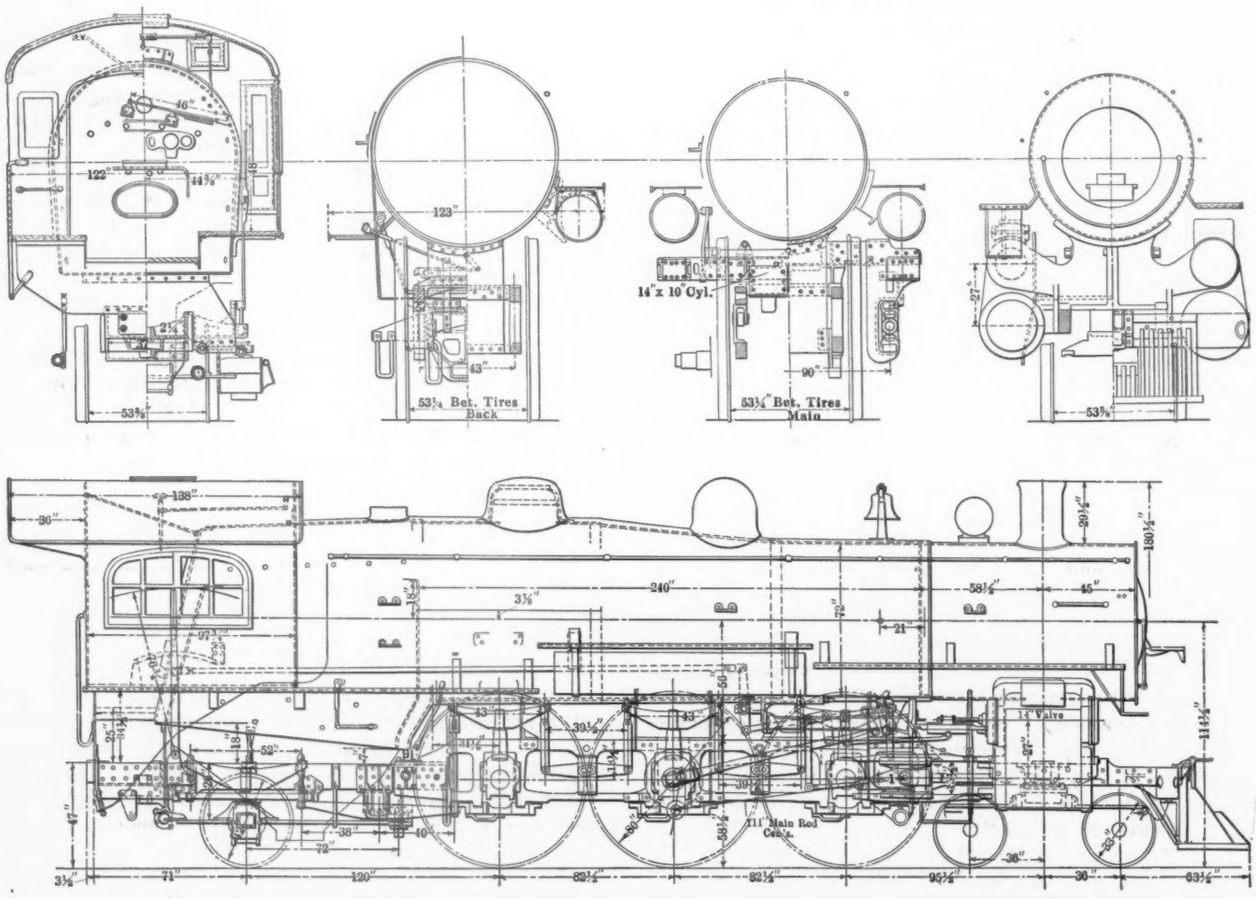
PACIFIC AND CONSOLIDATION TYPE LOCOMOTIVES.

Chicago and Alton Railway.

On page 399 of the October, 1908, issue of this journal appeared a very fully illustrated description of a design of Pacific type locomotive, five of which were built by the Baldwin Locomotive Works for the Chicago & Alton Railway. This design attracted much interested attention among motive power officials because it incorporated an old style narrow firebox on a very large modern high speed locomotive. The length and width of the firebox was 120⅞ x 40¼ in., giving a grate area of but 33 sq. ft. The locomotive had 23 x 28 in. cylinders, 200 lbs. steam pressure and a heating surface of 3,927 sq. ft. The ratio of heating surface to grate area was 119; a very large proportion gauged by modern practice.

It would seem that there is some doubt of the ability of these locomotives to handle some of the heaviest traffic on that railroad, which operates very high speed passenger trains, since the same company has just received five Pacific type locomotives from the American Locomotive Company which have wide fireboxes and a grate area of 49.5 sq. ft. The boiler in other respects is practically identical with that used on the previous order and the locomotives, as a whole, are very similar in size and power. They have 23 x 28 in. cylinders, 200 lbs. of steam and 80 in. instead of 73 in. drivers. By the use of the wide firebox it was possible to install 14 more tubes; the tube heating surface being thus increased to 4,071 sq. ft. The ratio of heating surface to grate area, however, has been reduced to 82.3, which, while still higher than the average for this type of locomotive, is not to be considered excessive, especially as this company is in a position to obtain a first-class grade of fuel.

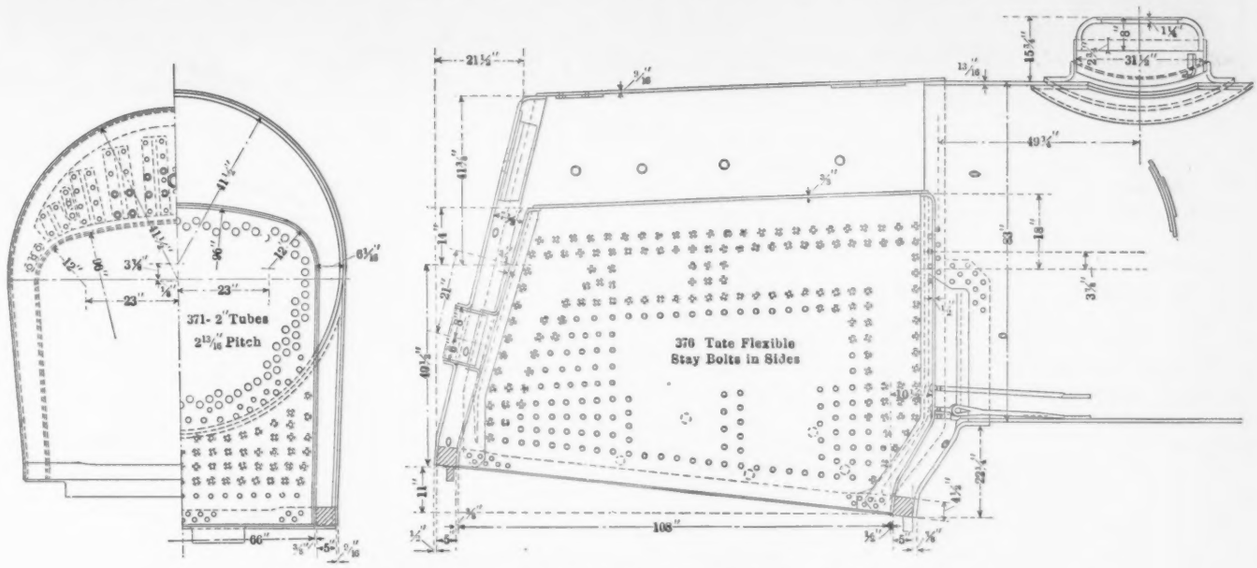
The construction of the later firebox is shown in one of the illustrations and it will be seen that while it is a typical wide firebox design it has outwardly inclining water legs, the firebox side sheet being 2 in. further out at the turn to the crown than



ELEVATIONS AND SECTIONS OF PACIFIC TYPE LOCOMOTIVE—CHICAGO AND ALTON RAILROAD.

at the mud ring, the space in the water leg at the same time being increased from 5 in. at the mud ring to 6 1/16 in. at the crown sheet. This will, to some extent, give the impinging action of the circulation in the water leg which it is believed is largely responsible for the good service of the ogee shape of side water legs.

This is one of the heaviest and most powerful Pacific type locomotives ever built, as a reference to the comparative table of locomotives in this issue will show. The total weight is 248,000 lbs., of which 149,500, or 60 per cent., is on driving wheels. The tractive effort is 31,475 lbs., giving a ratio of adhesion of 4.74. The B. D. factor of 618 falls well within the limits established by good practice.



DETAILS OF FIREBOX, PACIFIC TYPE LOCOMOTIVE—CHICAGO AND ALTON RAILROAD.

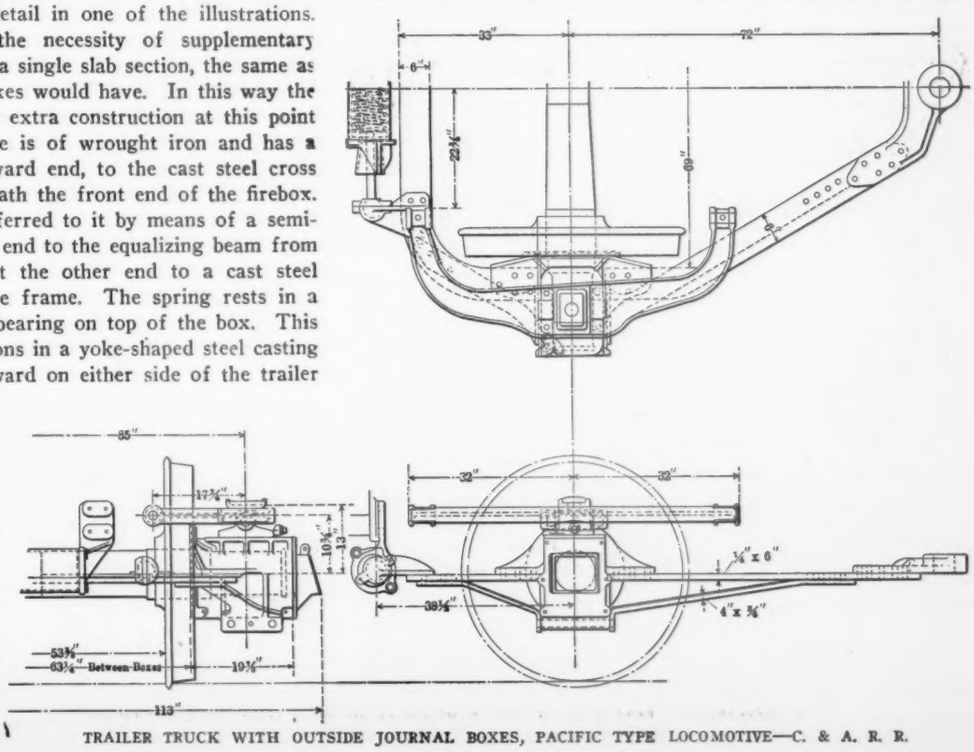
The frames are of wrought iron, consisting of a main frame 5 in. in width and a 2¼ in. slab form trailer frame spliced to the main frame just back of the rear pedestal. The main frame includes the single front rail which passes below the cylinders.

One of the most interesting features of this design is a new arrangement of trailer truck, which has outside boxes and inside frames. It is shown in detail in one of the illustrations. This arrangement eliminates the necessity of supplementary trailer frames and requires but a single slab section, the same as the trailer truck with inside boxes would have. In this way the complication and weight of the extra construction at this point is eliminated. The truck frame is of wrought iron and has a pivoted connection, at the forward end, to the cast steel cross tie between the frames underneath the front end of the firebox. The load on the truck is transferred to it by means of a semi-elliptic spring connected at one end to the equalizing beam from the rear driving spring and at the other end to a cast steel bracket extending out from the frame. The spring rests in a spring seat having a flat slide bearing on top of the box. This spring seat is carried by trunnions in a yoke-shaped steel casting of I-section, which extends inward on either side of the trailer wheel and is hinged in brackets secured to the frame. In this way the spring seat is able to easily adjust itself to the alignment of the box as the latter rises and falls relative to the frame. A spring centering device, the same as has previously been used by this company, is provided to bring the truck back to the normal center position after passing a curve.

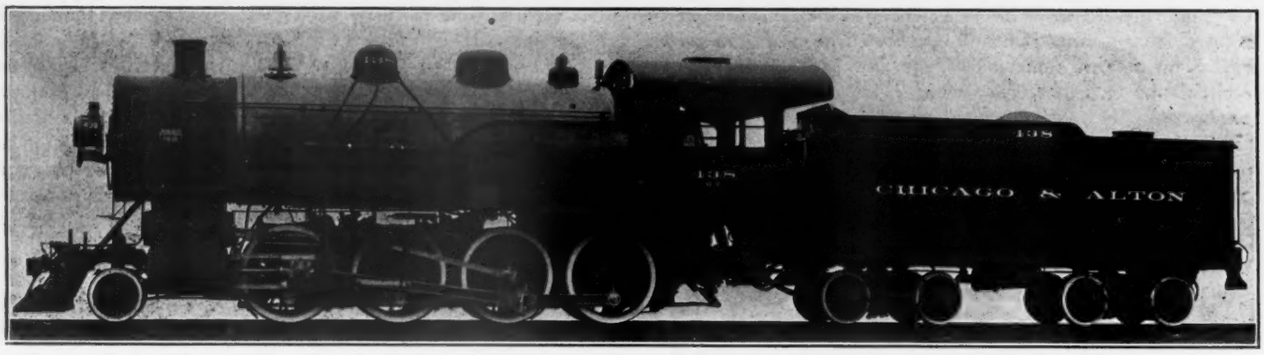
The valve gear is of the Baker Pilliod design, which was fully illustrated and described on page 32 of the January, 1909, issue of this journal. This valve gear has been tried out in practice on this road on this same type locomotive and its specification for this order indicates that the results have been satisfactory. The gear, in general, might be described as a combination of the Walschaert and Marshall valve gear, having incorporate in it features of both, but differing from either. It gives a constant lead and obtains its motion from a return crank the same as the Walschaert, but does not require a link or any sliding connections, all the motion being obtained by a system of levers having pin connections.

CONSOLIDATION LOCOMOTIVES.

Accompanying the order for the Pacific type locomotives was an order of ten consolidation engines which were delivered at the same time. That the application of the wide firebox to the Pacific type design does not indicate that this company has found the narrow type of firebox to be unsatisfactory is evidenced by the fact that the fireboxes on these locomotives, which have 22 x 30 in. cylinders, 200 lbs. steam pressure and



TRAILER TRUCK WITH OUTSIDE JOURNAL BOXES, PACIFIC TYPE LOCOMOTIVE—C. & A. R. R.



CONSOLIDATION TYPE LOCOMOTIVE WITH NARROW FIREBOX—CHICAGO AND ALTON RAILROAD.

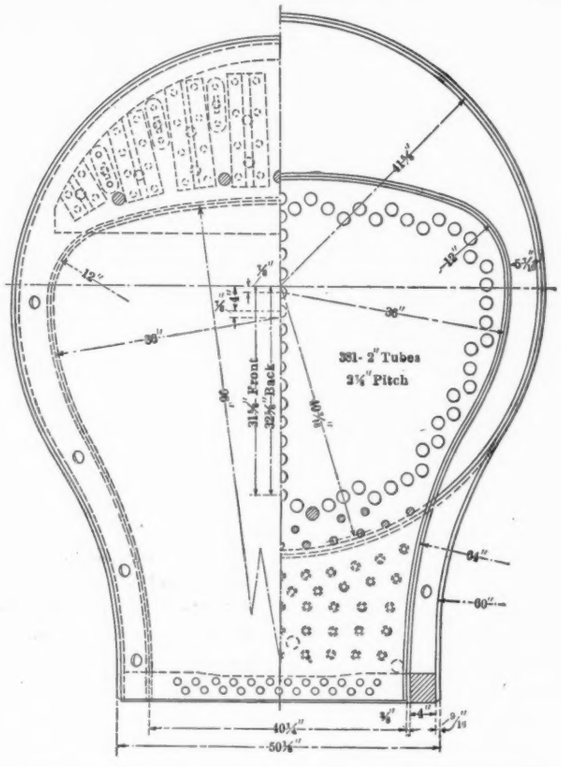
weigh 228,000 lbs., giving a tractive effort of 39,800 lbs., are 120½ in. long by 40½ in. wide, giving a grate area of 33.6 sq. ft., this being practically the same size grate as was used on the earlier order of Pacific type. The boiler itself is of the straight type, measuring 78⅜ in. inside diameter of the front sheet and 83¼ in. outside diameter at the dome course. The tubes are but 16 ft. in length, there being 381 2-in. tubes in the boiler, which gives a heating surface of 3,175 sq. ft. This with 197 sq. ft. in the firebox gives a total heating surface of 3,372 sq. ft. The ratio of heating surface to the grate area is 102, which is far larger than any other consolidation locomotive on our records. The B. D. factor, however, not being affected by the grate area, is normal.

The illustrations show the construction of this boiler and firebox very clearly and it will be seen that while the firebox side sheets have an ogee curve the radii used are large and there are no abrupt bends in the water legs. The mud ring is but 4 in. on the sides and the space is increased to 5 7/16 in. at the crown sheet. The crown and side sheets, both inside and outside, are in one piece.

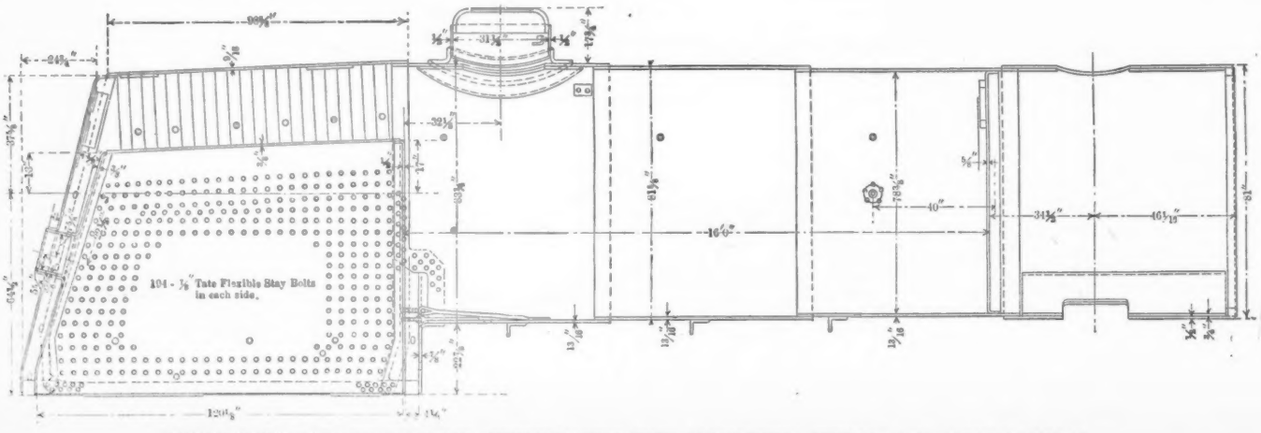
The frames in this case are also of wrought iron with an integral single front rail. The Baker Pilliod valve gear, being altogether outside of the frames, gives an opportunity for excellent frame bracing, which has been taken full advantage of.

The general dimensions, weights and ratios of both types of locomotives are given in the following table:

GENERAL DATA.		
Type	2—8—0	4—6—2
Gauge	4 ft. 8½ in.	4 ft. 8½ in.
Service	Freight	Pass.
Fuel	Bit. Coal	Bit. Coal
Tractive effort	39,800 lbs.	31,475 lbs.
Weight in working order	228,000 lbs.	248,000 lbs.
Weight on drivers	203,500 lbs.	149,500 lbs.
Weight on leading truck	24,500 lbs.	
Weight of engine and tender in working order	393,100 lbs.	413,120 lbs.
Wheel base, driving	17 ft. 9½ in.	13 ft. 9 in.
Wheel base, total	26 ft. 9½ in.	34 ft. 8½ in.
Wheel base, engine and tender	64 ft. 1 11/16 in.	66 ft. 4 in.
RATIOS.		
Weight on drivers ÷ tractive effort	5.10	4.74
Total weight ÷ tractive effort	5.72	7.90
Tractive effort × diam. drivers ÷ heating surface	730.00	618.00
Total heating surface ÷ grate area	102.00	82.30
Firebox heating surface ÷ total heating surface, %	5.83	4.98
Weight on drivers ÷ total heating surface	61.00	36.60
Total weight ÷ total heating surface	67.50	61.00
Volume both cylinders, cu. ft.	13.20	12.50
Total heating surface ÷ vol. cylinders	256.00	302.00
Grate area ÷ vol. cylinders	2.55	3.67
CYLINDERS.		
Kind	Simple	Simple
Diameter and stroke	22 x 30 in.	23 x 28 in.



SECTION THROUGH FIREBOX—C. & A. 2-8-0 LOCOMOTIVE.



LONGITUDINAL SECTION OF BOILER, CONSOLIDATION TYPE LOCOMOTIVE—CHICAGO AND ALTON RAILROAD.

VALVES.		
Kind	Piston	Piston
Greatest travel	5 in.	5 in.
Outside lap	1 in.	1 in.
Inside clearance	0 in.	0 in.
Lead, constant	¼ in.	¼ in.
Gear	Baker-Pilloid	
WHEELS.		
Driving, diameter over tires	62 in.	80 in.
Driving, thickness of tires	3½ in.	3½ in.
Driving journals, main, diam. and length	10½ x 12 in.	10½ x 12 in.
Driving journals, others, diameter and length	9½ x 12 in.	9 x 12 in.
Engine truck wheels, diameter	33 in.	33 in.
Engine truck, journals	6½ x 12¼ in.	6½ x 12¼ in.
Trailing truck wheels, diameter	———	42 in.
Trailing truck, journals	———	8 x 14 in.
BOILER.		
Style	Str.	E. W. T.
Working pressure	200 lbs.	200 lbs.
Outside diameter of first ring	80 in.	72 in.
Firebox, length and width	120⅛ x 40¼ in.	108 x 66 in.
Firebox plates, thickness	⅜ & ½ in.	⅜ & ½ in.
Firebox, water space	F.—4½, S. & B.—4 in.	5 in.
Tubes, number and outside diameter	381—2 in.	373—2 in.
Tubes, length	16 ft.	20 ft.
Heating surface, tubes	3,175 sq. ft.	3,869 sq. ft.
Heating surface, firebox	197 sq. ft.	202 sq. ft.
Heating surface, total	3,372 sq. ft.	4,071 sq. ft.
Grate area	33.6 sq. ft.	49.5 sq. ft.
Smokestack, diameter	18½ in.	18½ in.
Smokestack, height above rail	15 ft. ½ in.	15 ft. ½ in.
TENDER.		
Frame	13 in. Chan.	13 in. Chan.
Wheels, diameter	36 in.	36 in.
Journals, diameter and length	5½ x 10 in.	5½ x 10 in.
Water capacity	8,500 gals.	8,500 gals.
Coal capacity	14 tons.	14 tons

JACOBS-SHUPERT FIREBOX.

To the Editor:—

I notice in reading your June issue, a letter headed "Experience with the Jacobs-Shupert Locomotive Fire Box," and it would appear that the writer of it seems to be rushing things, for this experience to be printed in your June issue, for I was informed that this fire box was not finished and tried until the 26th or 27th of April, and this experience is ready for your June issue. It would be well to print this six months hence, as during that time they may have unsurmountable difficulties to contend with in a locomotive fire box constructed in that way. My name is referred to in reference to a letter I wrote giving my ideas of the construction of this fire box, and in it I actually made a challenge to the world on locomotive fire boxes and tube plates, and up to this time no one has taken it up. However, I cannot help remarking that your correspondent's letter is written in language and thought so much like the letters of Jacobs, Wagstaff, etc., that you would almost imagine that the letters over the different signatures referred to had come from the same pen. Referring to my experience, which is quoted by this corrspondent, it was with the Daniel Adamson's patent furnace joint, which came out, as near as I can remember, about 1869 or 1870, in England, and the Jacobs-Shupert fire box is nothing more than the old Adamson patent joint, with the center plate continued outward, for staying, which we used to call "plate staying." My experience with this joint was in marine and Lancashire double furnace boilers. These furnaces are round and do not require staying. The idea of this joint was to strengthen the furnaces by making them in sections so that they would not require reinforcing with tee iron rings, etc.

It is needless to repeat that my experience, and the experience of other well-known engineers, was not satisfactory, and hence my letter only referred to what I knew from actual facts.

I note your correspondent states how many stays are dispensed with in forming this locomotive fire box with this old joint, but he does not tell us that in place of the staybolts he has put twelve riveted seams, extending up sides and over crown of fire box, and has used about 5,000 or 6,000 rivets in place of the stays. He tells us he has gained 21 inches in the length of the same sized fire box, but he does not tell us there is about 19 square feet of direct heating surface taken up by the twelve joints which is practically lost, but he does say that the contraction and expansion of the fire box will be equalized by the formation of these sections. The sections are riveted together, and at the bottom they are welded together (two things which do not harmonize) in order to allow the sections to be riveted in the mud ring.

My views differ from your correspondent's, that the formation of the sections will equalize the contraction and expansion of the box. I predict the expansion of the sections will all go toward the fire box tube plate, and that the front tube plate and the tubes will expand in the opposite direction toward the fire box tube plate, two opposing forces, meeting on the same tube plate, just the same as there is now in the standard fire box, and no provision made to take care of it. The sections, with the twelve riveted seams, the rivets of which you will find will incrustate, and the joint surrounded by scale, will burn and the sections will crack, and the sections cannot do otherwise than form mud pockets. Experience repeats itself.

Your correspondent states that I stated, that in designing a fire box I eliminated most of the parts that they have incorporated. And why did I do it? Because I deemed it requisite for success, and I can assure you it was a hard problem to feel sure that I had balanced the contraction and expansion in a locomotive fire box from front tube plate to back of fire box, and I studied hard for two years before I was satisfied to allow my name to be associated with it. When I was sure, I let her go, and by actual practice it is proving my experience, and is telling its own tale by the success with which the boilers are doing their work, as can be seen by referring to the locomotive expert's report, copy of which is given to this paper.

In conclusion, I wish to be put on record that the Jacobs-Shupert fire box will be a costly experiment for the Atchison, Topeka & Santa Fe Railroad Co., and one that will call for criticism from all parts of the engineering world, and I feel sure time will soon eradicate the sagacity of the remarks made on this subject by the writers referred to above.

WM. H. WOOD.

Media, Pa.

[The locomotive expert's report referred to above by Mr. Wood is substantially as follows:—ED.]

I have been engaged by the Wm. H. Wood Locomotive Fire Box and Tube Plate Co. to examine locomotives Nos. 2490, 2494 and 2481 respectively, equipped with the Wm. H. Wood patented fire box and tube plates, as well as engines Nos. 2487, 2492 and 2499, which have the ordinary fire box and are operating the same trains with the former three.

I have found the locomotives with the Wood fire box as compared with those of the standard fire box to be better steamers, to be coal savers, as is shown below and to be most satisfactory to the engineers and firemen operating them, who all speak in the highest praise of the working of these boilers. I have found the beading on the flues to be just as good after six months' service as they were when the engines were turned out, and although the flues have been rolled I have the evidence of the engineers that they have not reported a flue leaking in eight weeks' service and that the flues did not require rolling. There has not been a broken staybolt in these boilers since they were put into service. One staybolt in the throat sheet was removed because of the tell-tale hole being drilled at an angle. I have not found any leaks at the mud ring, and, in spite of the fact that the water being used is very poor, the boilers have not leaked in any respect as far as I have been able to discover.

I have carefully determined the amount of coal used on these engines, especially two equipped with the Wood fire box and two with the regular fire box, having boarded the engine upon its arrival and measured the volume of the coal left in the tender and determined how much had been used on these four engines. This has been done daily and the results are as follows:

No. 2481 (Wood's fire box), the average amount of coal consumed on each of fifteen trips, from April 23 to June 1, has been 5.67 tons.

No. 2492 (ordinary fire box), fifteen trips with the same trains and in exactly the same service, 9.01 tons.

No. 2490 (Wood's fire box), fifteen trips, 7.2 tons.

No. 2487 (ordinary fire box), fourteen trips, 8.62 tons.

Taking No. 2492 as a basis, engine No. 2481 shows a coal economy of 37 per cent. and engine No. 2490 an economy of 20 per cent.

Engine No. 2494 (Wood's fire box) is running opposite No. 2499 (ordinary fire box) and shows an average consumption of 9.35 tons per trip in two trips as compared with an average of 13.3 tons per trip in three trips of the No. 2499, an economy of about 30 per cent.

(Signed) FRED. H. SNELL,
Locomotive Expert.

To the Editor:—

So much has been said by correspondents in the columns of your paper concerning the circulation of water in the Jacobs-Shupert fire box that I feel impelled to present to these correspondents, and others, several photographs which tell a graphic story, and which still further illustrate the beneficial effect of the sectional construction upon circulation and upon the life of boilers.

The accompanying illustrations of an old fire box show very clearly how solids contained in feed water are collected by obstructions which impede circulation. The crown sheet is the hottest portion of the fire box, and ebulition above the crown sheet is vigorous and active, and any obstructions to the movement of the heated water and steam bubbles, as they rise from the crown sheet, produce eddies in the currents of rising steam and water, providing harbors where solid substances may collect undisturbed. Each particle that collects forms a nucleus to which other particles adhere.

This formation not only materially diminishes the evapora-

tive value of the crown sheet and lowers the capacity of the boiler, but introduces an element of danger. Such accumulations are conducive to explosions, and an accumulation of mud and scale immediately upon the crown sheet is likely to cause mud burns, even though the water in the boiler is at the proper level.

The photographs therefore emphasize the necessity of unimpeded circulation above the crown sheet, and illustrate what takes place in locomotive boilers wherein the circulation above the crown sheet is impeded.

A side view of the Jacobs-Shupert fire box, in connection with the photographs just referred to, forms a striking comparison between a form of boiler construction wherein circulation above the crown sheet is impeded and a construction wherein there is practically no obstruction to the free movement of water and steam. Not only are the stay sheets of the Jacobs-Shupert fire box few in number and spaced far apart, but they are of a form which will neither harbor solids nor interfere with the free movement of currents rising from the crown sheet.

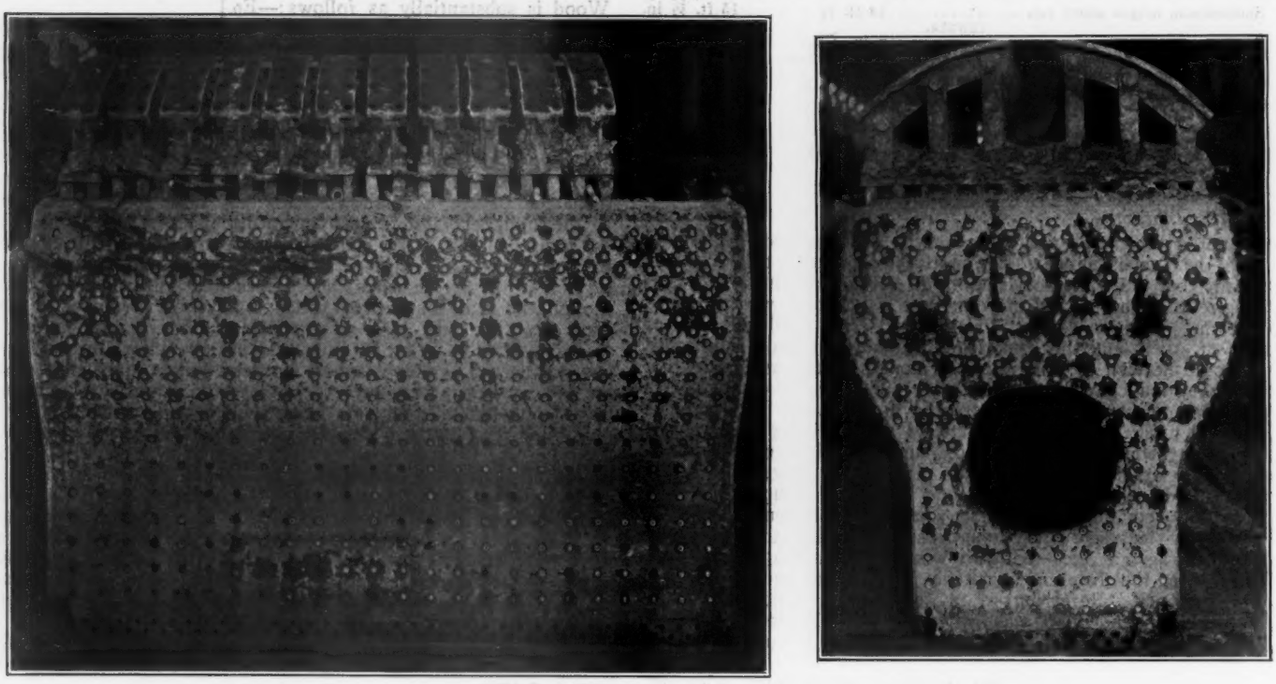
A still further advantage which this comparison emphasizes is the increased heating surface provided by the Jacobs-Shupert design. The total area covered by the crown-bar washers of the old fire box is 6.08 square feet. The area above the crown sheet occupied by the radial stay sheets of the Jacobs-Shupert fire box is only 2.26 square feet in a fire box 129⅝ inches long. The size of this crown sheet is materially larger than that of the old fire box, so that for a crown sheet of the same size the proportional gain in heating surface is even greater than that indicated by the above figures.

It is true that in boilers with radially stayed crown sheets, the stays do not offer the same amount of obstruction as the crown bars. Nevertheless, several rows of radial stays are usually replaced by three or four rows of sling stays at the forward end of the crown sheet. T-irons of these sling stays impede circulation as much as the ordinary crown bar and produce the same effect upon the accumulation of mud and scale. This formation is at the point of the crown sheet where the greatest difficulty from cracking occurs and is, therefore, the point where there should be the least accumulation of mud.

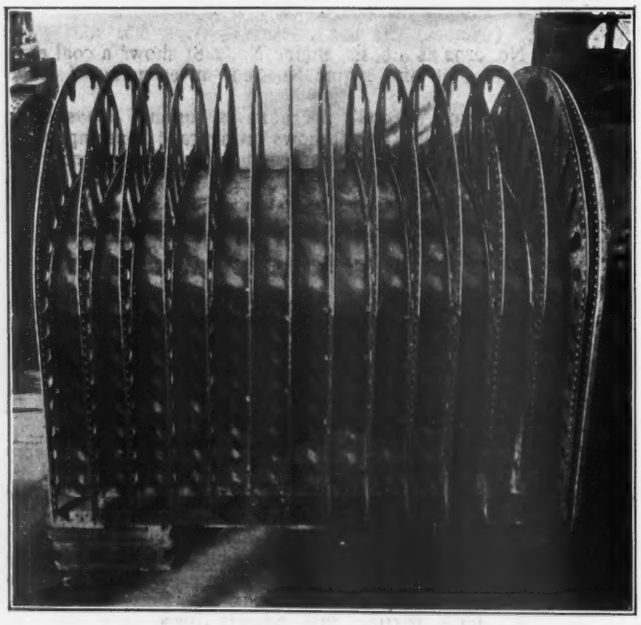
While the straight radial stay does not cause the same accumulation as the crown bar or the T-iron, the large number of stays offers much more impediment than the few thin stays of the Jacobs-Shupert construction and consumes more space which would otherwise be available as heating surface. Another objection to the radial stay is the crown head on the fire side of the crown sheet, which is always a prolific source of trouble.

H. W. JACOBS.

Topeka, Kan.



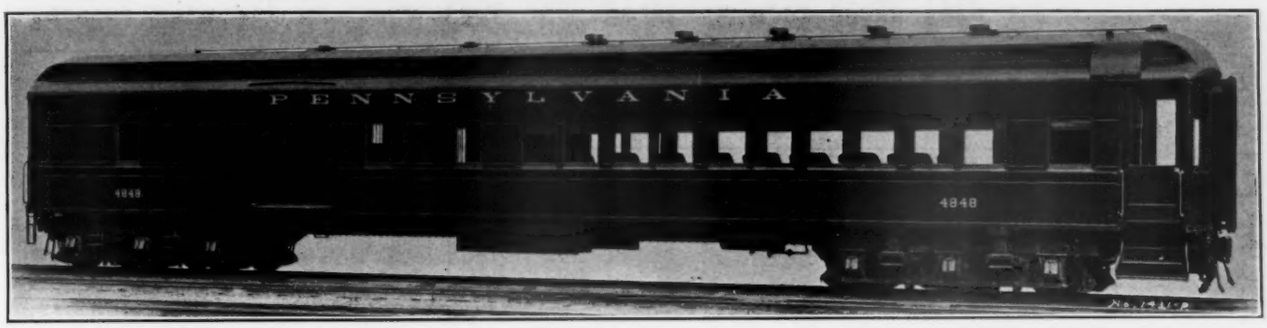
FIREBOX OF CROWN BAR BOILER SHOWING ACCUMULATION OF SCALE AND SEDIMENT.



SIDE VIEW OF JACOBS-SHUPERT FIREBOX.

THE VALUE OF THE RAILROAD CLUB.—The officials of one road rub elbows with the officials of another, they compare notes, they learn how one man does the same thing they are doing in a different way, and does it with less actual labor or less wear and tear on his gray matter or reasoning powers, and the result to the employee is a capacity for greater responsibility, and to the company a more competent officer.—*A. W. Martin, New England Railroad Club.*

EXPLOSION FROM BELT FRICTION.—An overlooked factory danger has been pointed out in Germany by Prof. M. M. Richter, who has found that machinery belts—especially in dry air and when rubbed with resinous substances—may become highly charged with electricity, and may give off sparks that, in an atmosphere laden with dust or combustible vapors, may produce a serious explosion. A five-inch belt running over a wheel making 600 to 2,000 revolutions a minute gave off a spark one to one and a half inches long. Coating the belts with bronze or aluminum powder proved an ineffective preventive, but acid-free glycerin, applied once a week, attracted moisture, and not only gave security against static charges, but increased the life of the leather.—*American Machinist.*



PENNSYLVANIA ALL-STEEL COMBINATION PASSENGER AND BAGGAGE CAR.

In the June and July issues, 1907, the all-steel passenger cars for the Pennsylvania Railroad, including a through service passenger coach, a postal car, baggage car and suburban car, were described in detail. A number of combination passenger and baggage cars designed along the same lines have recently been manufactured for this company by the Pressed Steel Car Company. The general dimensions of these cars are as follows:

Length over all.....77 ft. 8¾ in.
Length over body corner posts.....71 ft. 1 1/16 in.
Length inside, passenger end.....39 ft. 9 11/16 in.
Length inside, baggage end.....35 ft. 6 in.
Width over side sheets.....9 ft. 9¼ in.
Height from rail to top of car.....14 ft. ½ in.

These cars have been constructed almost exclusively of steel, including the doors. The floors and headlinings are of fireproof material, and the very small percentage of inflammable material used is not a part of the structure, but merely of the trimming. In the main structure of each combination coach there have been used 17,500 lbs. of ¼-in. plates, 4,500 lbs. of angles, and 7,100 lbs. of shapes and small plates. In addition, considerable steel material for interior finishing has been utilized. The flooring consists of monolith laid on corrugated sheets. A ¾-in. maple floor is placed upon the monolith at the baggage end.

Six-wheel trucks are used having 5 x 9-in. axles and 36-in. Carnegie-Schoen rolled steel wheels.

SEAT ARMS AND WINDOW SILLS ON STEEL PASSENGER CARS.—The use of steel for window sills and arm rests on seat ends is not only objectionable because these parts soon lose their paint due to constant elbowing, but it has been found that steel is too cold in winter time to make comfortable supports for the arms and hands of the passengers; cars which were originally equipped with these parts of steel are now being changed to wood.—*Chas. Lindstrom, Central Railway Club.*

RAILROAD CLUB STATISTICS

		Canadian	Central	Iowa	New England	New York	Northern	Pittsburgh	Richmond	St. Louis	Western
ANNUAL MEETING, NUMBER		7th	19th	.....	26th	35th	3rd	7th	7th	13th	25th
ANNUAL MEETING, DATE OF		May, '09	Jan , '09	.....	Mar., '09	Nov., '08	Nov., '08	Oct., '08	Nov., '08	April, '09	May, '09
MEMBERS	Number Received During Year	122	185	.....	70	174	244	107	53	142	183
	Total Membership, Active	722	569	273	515	1,416	529	742	236	1,202	1,574
	Net Gain for the Year	14	142	.....	23	66	.....	.....	19	54	74
RECEIPTS	Balance on Hand, previous report	$1,501.22	$105.89	$55.12	$1,319.93	$13,307.14	$111.41	$898.81	$1,315.07	$3,968.41	$1,917.58
	Dues and Fees	1,238.00	1,167.00	766.75	1,232.00	3,451.00	753.00	2,202.00	442.00	2,206.00	.....
	Advertising	3,158.20	1,756.00	277.00	2,625.00	4,678.88	1,405.00	882.75	1,140.00	1,839.77	.....
	Miscellaneous	224.37	322.65	1,288.75	1,257.21	701.44	135.00	85.33	77.14	163.65	4,791.18
	Total	6,121.79	3,351.54	2,387.62	6,434.14	22,138.36	2,404.41	4,068.89	2,974.21	8,177.83	6,708.76
DISBURSEMENTS	Printing and Stationery, Postage	$1,659.29	$1,143.32	.....	$1,547.65	$3,335.44	$867.48	$1,786.15	$457.91	$1,919.82	$2,581.28
	Entertainment	709.70	1,005.05	.....	2,147.32	1,553.85	290.70	607.14	117.00	985.83	.....
	Salaries and Stenographer	812.49	650.00	.....	1,148.50	1,619.77	494.45	135.00	702.00	542.95	556.93
	Miscellaneous	652.90	254.63	.....	47.97	803.72	163.00	170.25	45.00	586.98	2,533.39
	Total	3,834.38	3,053.00	$2,332.68	4,891.44	7,312.78	1,815.63	2,698.54	1,321.91	4,035.58	5,671.60
Balance on Hand		$2,287.41	$298.54	$54.94	$1,542.70	$14,825.58	$588.78	$1,370.35	$1,652.30	$4,142.25	$1,037.16

Canadian Railway Club maintains a scholarship at McGill University. *Iowa.*—During the year covered by the above report the club held a reunion in conjunction with the Des Moines Commercial Club. This accounts for the apparently heavy receipts under the head of "Miscellaneous." *New England.*—This club has a dinner before each meeting. $1,125.25 under "Miscellaneous" receipts was received from the members for this purpose and for tickets to an "outing." *Richmond.*—About $400.00 should be added to expenditures for entertainment. *St. Louis* maintains a scholarship at one of the colleges. *Western* presents its members annually with bound volumes of the proceedings.

MEETINGS

Canadian—First Tuesday in month except June, July, August.
Central—Second Friday, Jan., Mar., May, Sept., and Nov.
Iowa—Second Friday in month except July and August.
New England—Second Tuesday except June, July, Aug. and Sept.
New York—Third Friday except June, July and August.
Northern—Fourth Saturday in each month.
Pittsburgh—Fourth Friday except June, July and August.
Richmond—Second Monday except June, July and August.
St. Louis—Second Friday except June, July and August.
Southern & Southwestern—Third Thursday, Nov., Jan., April and Aug.
Western—Third Tuesday except June, July and August.
Western Canada—Second Monday except June, July and August.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED IN ORDER OF TOTAL WEIGHTS

FREIGHT LOCOMOTIVES OF THE CONSOLIDATION OR 2-8-0 TYPE

Name of road	N. Y. S & W	D. & H.	W. P. T.	L. S. & M. S.	L. S. & M. S.	C. & A.	P. R. R.	Wabash	A. T. & S. F.	B. & O.	Har. lines	C. S. N. O. & P.	P. R. R.	C. N. O. & T. P.	C. B. & Q.	W. P.	C. R. I. & P.	C. P. R.
Road number or class	140	1,011	918	5,962	G-46	438	2.762		1,950	2,503	C-187		H 6 B	734	D4		55D	M4
Builder	Bald.	Amer.	Amer.	Amer.	Amer.	Amer.	Amer.	Bald.	Bald.	Amer.	Bald.	Bald.	Bald.	Both	Amer.	Bald.	Bald.	Shops
When built	1906	1906	1909	1906	1903	1909	1905	1906	1908	1905	1905	1907	1905	1907	1903	1906	1906	1904-6
Simple or compound	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	54,100	49,690	46,900	45,677	46,500	39,800	45,700	42,600	44,000	41,100	43,299	43,300	42,000	44,100	42,500	44,100	39,600	36,800
Weight, total, lbs	260,100	246,500	236,000	232,500	230,000	228,000	220,000	214,500	212,400	208,500	208,000	207,000	204,470	203,600	202,600	201,330	198,600	186,200
Weight on drivers, lbs	232,700	217,500	207,000	207,000	203,000	203,500	198,000	189,600	183,200	185,900	187,000	182,000	181,170	182,000	179,200	186,330	177,300	163,700
Weight on trucks, lbs	27,400	29,000	29,000	25,500	27,000	24,500	22,000	24,900	29,200	22,600	21,000	27,000	23,300	21,600	23,400	15,000	21,300	22,525
Weight, tender loaded, lbs	161,900	152,400	154,000	149,600	148,000	165,100	140,500		175,200	143,500	135,050	148,000	143,000	146,400	150,200		140,300	121,400
Wheel base, driving	17′ 0″	17′ 0″	15′ 9″	17′ 6″	17′ 3″	17′ 9½″	17′ 6″	15′ 9″	15′ 6″	16′ 8″	15′ 8″	16′ 0″	16′ 3″	16′	15′ 8″	15′ 8″	17′ 0″	15′ 10″
Wheel base, engine	26′ 6″	25′ 11″	25′	26′ 5″	26′ 5″	26′ 9½″	26′ 5″	24′ 6″	24′ 6″	25′ 7″	24′ 4″	24′ 4″	34′ 9″	24′ 3½″	24′ 6″	24′ 4″	26′ 0″	24′ 4½″
Wheel base, engine and tender	60′ 10″	57′ 7½″	59′ 11″	60′ 9¾″	57′ 9¾″	64′ 1 11/16″	60′ 3¾″	57′ 10½″	58′ 5″	59′ 8¼″	55′ 11¾″	56′ 3″	58′ 1½″	56′ 7¼″	69′ 1¾″	57′ 11½″	58′ 0″	53′ 4¾″
Diameter of drivers	63″	57″	58″	63″	58″	62″	63″	58″	57″	60″	57″	57″	56″	56″	57″	57″	63″	57″
Cylinders, number	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Cylinders, diameter and stroke	28″ × 32′	23″ × 30″	25″ × 32″	23″ × 32″	23″ × 30″	22″ × 30″	23″ × 32″	22″ × 30″	24″ × 32″	22″ × 30″	22″ × 30″	22″ × 30″	22″ × 28″	22″ × 30″	22″ × 28″	22″ × 30″	23″ × 30″	21″ × 28
Valve gear, type	Wals.	Wals.	Wals.	Wals.	Steph.	Pilloid	Steph.	Steph.	Wals.	Steph.	Steph.	Wals.	Wals.	Wals.	Steph.	Steph.	Wals.	Steph.
Steam pressure, lbs	160	210	160	200	200	200	200	200	160	205	200	200	205	200	210	200	185	200
Boiler, type	Str.	Wooten	E. W. T.	Rad. stay	W. T.	Str.	Str.	W. T.	Str.	Str.	Str.	Str.	Belp.	Str.	Str.	Str.	E. W. T.	E. W. T.
Boiler, smallest diameter	84″	83¾″	80″	81⅝″	80″	80″	80″	77″	78¾″	74′ 5″	80″	78″	71″	76 1/16″	79½″	80″	74″	69″
Boiler, height center	120″	113″		118¼″	119½″		117″		114″	118″	114″	115½″	108¼″	114⅞″	115″		117″	111½″
Heating surface, tubes, sq. ft	3,931	3,716	3,093	3492.18	3,725	3,175	3,600	3,053	2,773	2630.1	3,226	2,939	2675.9	3,051	3511.56	2,927	2,427	2,216
Heating surface, firebox, sq. ft	198	329.5	190	213.05	232	197	182	192	157	179.3	177	183	166.5	175	221.77	214	168	165
Heating surface, total, sq. ft	4,129	4045.5	3,283	3705.23	3,957	3,372	3,782	3,245	2,930	2809.4	3,403	3,122	2842.4	3,226	3733.33	3,141	2,595	2,381
Heating surface, superheater, sq. ft	834		374			118½″			600									375
Grate area, sq. ft	60.2	99.85	50.5	56.5	55	33.6	55.4	50.4	47.4	56.24	49.5	51	49.11	54	54.2	33.6	50	43
Firebox, length	120″	126⅛″	109″	108⅛″	108″	120½″	106″	108½″	95½″	107⅝″	108″	108″	107″	108″	108¾″	121″	107″	96⅝″
Firebox, width	72¼″	114″	68″	75¼″	73¾″	40½″	75¼″	67¼″	71¾″	75¾″	66″	68″	66″	71¾″	72″	40″	67¾″	65¾″
Fuel, kind	Bit. coal	Anth. coal	Bit. Coal.	Bit. coal	Bit. coal	Bit. Coal	Bit. coal	Bit. coal	Oil	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	472	493	358	446	461	381	446	360	355	282	413	386	373	403	450	390	340	244
Tubes, number superheater			20															22
Tubes, diameter, firetube	2″	2″	2″	2″	2″	2″	2″	2¼″	2″	2¼″	2″	2″	2″	2″	2″	2″	2″	2″
Tubes, diameter, superheater			5¼″															5″
Tubes, length	16′	14′ 6″	14′ 6″	15′	15′ 6⅛″	16′	15′ 4¾″	14′ 6″	14′ 11″	15′ 10″	15′	14′ 6½″	13′ 8½″	14′ 6½″	15′	14′ 5″	15′ 6″	14′ 1⅜″
Tender, coal capacity, tons	15	14	14	12	16	14	13½		3,300 G	15	14	12	13½	12½	14	14	12	10
Tender, water capacity, gals	9,000	7,800	8,000	7,500	7,500	8,500	7,000	8,000	8,500	7,000	7,000	7,500	7,000	7,500	8,000	8,000	7,000	5,000
Weight on drivers ÷ tractive effort	4.3	4.37	4.41	4.5	4.37	5.10	4.3	4.44	4.17	4.5	4.3	4.2	4.3	4.13	4.2	4.2	4.5	4.4
Weight, total ÷ tractive effort	4.8	4.97	5.03	5.0	4.95	5.72	4.8	5.	4.75	5.1	4.8	4.76	4.8	4.61	4.8	4.55	5.	5.1
T. E. × diam. drivers ÷ total H. S.	825.	700.	825.00	775.	680.	730.00	760.	760.	855.	875.	725.	790.	830.	768.	650.	800.	965.	800.
Total heating surface ÷ grate area	68.50	40.5	65.00	65.8	72.	102.00	68	64.	62.	50.	69.	61.	58.	59.80	69.	93.	52.	55.
Firebox heat. surf. ÷ total H. S. %	4.80	8.12	5.80	5.75	5.85	5.82	4.82	5.9	5.35	6.35	5.2	5.85	5.9	5.42	5.9	6.8	6.5	6.9
Weight on drivers ÷ total heat. surf	56.	53.5	63.00	55.8	51.2	61.00	52.	58.	62.50	66.	55.	58.2	63.5	56.40	48.	59.5	68.	69.5
Weight total ÷ total heating surface	63.	60.8	71.70	6.25	58.	67.50	58.	66.	72.50	74.	61.	66.	72.	63.	54.	64.	77.	78.
Total H. S. ÷ superheating heat. surf.	5.		8.78						4.90									6.35
Cylinder volume, cubic feet	22.70	14.4	18.20	15.4	14.4	13.20	15.4	13.2	16.80	13.2	13.2	13.2	12.4	13.20	12.4	13.2	14.4	11.2
Total heating surface ÷ cyl. volume	181.	280.	181.00	242.	275.	256.00	246.	246.	174.50	213.	259.	236.5	229.	244.06	302.	238.	180.	213.
Superheating heat. surf. ÷ cyl. vol.	36 8		20.6						35.5									33.3
Grate area ÷ cylinder volume	2.65	6.92	2.78	3.66	3.8	2.55	3.6	3.8	2.82	4.3	3.75	3.87	3.95	4.10	4.4	2.55	3.48	3.8
Reference in THE AMERICAN ENGINEER	1907 p. 302	1907 p. 22	1909 p. 256	1906 p. 263	1903 p. 415 1904 p. 11	This issue	1906 p. 73		1908 p. 112	1906 p. 31	1905 p. 154	1907 p. 194	1906 p. 231	1908 p. 26	1903 p. 48		1907 p. 147	1906 p. 165

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

FREIGHT LOCOMOTIVES OF TYPES OTHER THAN THE CONSOLIDATION

TYPE	MALLET 2-8-8-2	MALLET 0-8-8-0	MALLET 2-6-6-2	MALLET 2-6-6-2	MALLET 0-6-6-0	MALLET 2-6-6-0	MALLET 0-6-6-0	MALLET 2-6-6-2	SANTA FE 2-10-2	MIKADO 2-8-2	MIKADO 2-8-2	MIKADO 2-8-2	12-WH'L 4-8-0	10 WHEEL 4-6-0	10 WHEEL 4-6-0	SWITCHING 0-10-0	SWITCHING 0-8-0	SWITCHING 0-6-0
Name of road	S. P.	Erie	G. N.	Mex. Cent.	B. & O.	V. R. R.	D.N.W.& P	G. N.	P. S. & N.	N. P.	C.M. & St. P.	V. R. R.	N. & W.	T. & P.	C. & E. I.	L.S. & M.S.	C. & O.	P. & L. E.
Road number or class	4,000	2,600	I,-1	H	2,400		200		98	1,608	5202	421	N1	375	289	M.	8	253
Builder	Bald.	Amer.	Bald.	Bald.	Amer.	Amer.	Amer.	Bald.	Bald.	Amer.	Shops	Baldwin	Both	Amer.	Bald.	Amer.	Amer.	Amer.
When built	1909	1907	1906	1908	1904	1909	1909	1907	1907	1906	1909	1909	1907	1907-8	1905	1905	1903	1906
Simple or compound	Comp.	Comp.	Comp.	Comp.	Comp.	Comp.	Comp.	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Bal. comp.	Simple	Simple	Simple
Tractive effort, lbs	94,640	94,800	71,600	71,600	70,000	70,800	74,130	57,760	60,000	46,630	46,630	50,350	40,163	38,400	31,000	55,300	41,000	44,100
Weight, total, lbs	425,900	410,000	355,000	338,000	334,500	330,000	327,500	288 000	288,000	261,000	260 500	254,000	200,000	197,000	191,060	270,000	171,175	178,200
Weight on drivers, lbs	394,150	410,000	316,000	300,000	334,500	312,000	327,500	250,000	235,000	205,000	201,000	207,450	168,000	165,000	145,260	270,000	171,175	178,200
Weight on trucks, lbs	14,500		19,000	19,000		18,000		18,000		26,000	25,500	20,850	32,000	32,000	45,800			
Weight on trailer, lbs	17,250		20,000	19,000				20,000		30,000	34,000	25,700						
Weight, tender loaded, lbs	170,100	167,700	148,000	157,000	143,000	162,300	159,800	152,000	162,000	177,800	154,000	173,000	116,600	132,867	120,000		121,160	121,300
Wheel base, driving	39′ 4″	14′ 3″	10′ 0″	9′ 2″	10′ 0″	11′ 0″	10′ 0″	9′ 10″	19′ 9″	16′ 6″	16′ 6″	15′ 6″	15′ 6″	14′ 10″	13′ 6″	19′ 0″	13′ 7½″	12′ 0″
Wheel base, engine	56′ 7″	39′ 2″	44′ 10″	44′ 2″	30′ 8″	39′ 11″	30′ 8″	43′ 7″	35′ 11″	34′ 9″	35′ 1″	33′	26′ 5″	26′ 4″	27′ 7″	19′ 0″	13′ 7½″	12′ 0″
Wheel base, engine and tender	83′ 6″	70′ 5½″	73′ 2½″	70′ 11″	64′ 7″	73′ 2 1/8″	64′ 4″	72′ 0¾″	67′ 4½″	63′ 1″	65′ 7½″	65′ 10¾″	53′ 7″	55′ 9¼″	55′ 8″	54′ 5½″	45′ 8″	46′ 2¼″
Diameter of drivers	57″	51″	55″	55″	56″	54″	55″	55″	57″	63″	63″	56″	56″	63″	62″	52″	51″	50″
Cylinders, number	4	4	4	4	4	4	4	4	2	2	2	2	2	2	4	2	2	2
Cylinders, diameter	26″ & 40″	25″ & 39″	21½ & 33″	21½″ & 33″	20″ & 32″	22″ & 35″	20½″ & 33″	20″ & 31′	28″	24″	24″	24″	21″	22″	15½″ & 26″	24″	21″	21″
Cylinders, stroke	30″	28″	32″	32″	32″	30″	32″	30″	32″	30″	30″	32″	30″	28″	26	28″	28″	30″
Valve gear, type	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Wals.	Steph.	Wals.	Steph.	Steph.
Steam pressure, lbs	200	215	200	200	235	200	225	210	160	200	200	180	200	210	225	210	200	200
Boiler, type	Str.	Str.	Belp.	Str.	Str.	E. W. T.	Str.	Belp.	E. W. T.	E. W. T.	E.W. T.	Str.	W. T.	E. W. T.	W. T.	W. T.	W. T.	Str.
Boiler, smallest diameter	84″	84″	84″	78″	84″	76″	84″	72″	78¾″	75¾″	75¾″	78¾″	70″	70⅛″	64″	80⅛″	67″	80″
Boiler, height center	120″	120″	120″		120″	116″	120″	116″	118″	118″	118″	112″	112″	114⅝″	109″	115″	112½″	108½″
Heating surface, tubes, sq. ft	4,941	4,971.5†	5,473	4,311	5,380	4,842	5,035	3,708	4,586	3,192	3,332	4,277	2,605	2,731	2,933.7	4,422.6	2,573	2,906
Heating surface, firebox, sq. ft	232	343.2	230	201	220	223.9	206	198	210	245 †	282†	189	173	200	160.7	197.	164	206
Heating surface, total, sq. ft	6,393	5,313.7	5,703	4,512	5,600	5,065.9	5,241	3,906	4,796	3,437	3,614	4,466	2,778	2,931	3,094.4	4.619.6	2.737	3.112
Heating surface, superheater, sq. ft	655								762									
Grate area, sq. ft	68.4	100	78	61	72.2	57	72.2	53.4	58.5	43.5	48.8	51	45	46.3	46.69	55.4	38.8	33.3
Firebox, length	126″	126⅛″	117″	123½″	108⅛″	114″	108″	116⅛″	108″	96″	107″	102″	99⅛″	99″	101⅞″	108⅛″	80″	120″
Firebox, width	78¾″	114¼″	96″	71″	96¼″	72″	96″	66¼″	78″	65¼″	65¾″	72″	64⅛″	67¼″	66″	73¾″	70″	40″
Fuel, kind	Oil	Bit. Coal.	Bit. Coal.	Oil	Bit. Coal	Bit. Coal.	Bit. Coal	Bit. Coal	Bit. Coal	Bit. coal	Bit. Coal	Bit. Coal.	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	401	404	441	350	436	390	409	301	391	372	366	374	242	326	278	447	351	430
Tubes, number superheater																		
Tubes, diameter, firetube	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2″	2″	2¼″	2¼″	2″	2¼″	2″	2″	2″
Tubes, diameter, superheater																		
Tubes, length	21′	21′	21′	21′	20′ 10¾″	21′	21′	21′ 0″	20′ 0″	16′6″	17′ 6″	19′ 6″	18′ 4⅞″	16″	18′ 0″	19′ 0″	14′ 0″	13′ 0″
Tender, coal capacity, tons	2,850	16	13	3,500	16	14	12	13	14	12	14	16	10	12	12	12	7	10
Tender, water capacity, gals	9,000	8.500	8,000	8.000	7,000	9,500	9,000	8,000	8,500	10,000	8,000	9,500	6,000	6.500	6,000	8,000	6,000	7,000
Weight on drivers ÷ tractive effort	4.18	4.32	4.4	4.20	4.75	4.41	4.4	4.34	3.91	4.38	4.31	4.10	4.20	4.30	4.67	4.86	4.15	4.04
Weight, total ÷ tractive effort	4.51	4.32	4.95	4.70	4.75	4.67	4.4	5.00	4.8	5.6	5.80	5.05	4.98	5.13	6.15	4.86	4.15	4.04
T. E. × diam. drivers ÷ total H. S	843.	910.	690.	873.	700.	753.	780.	813.	712.	855.	812.80	631.00	810.00	825.00	620.	625.	763.	710.
Total heating surface ÷ grate area	93.40	53.14	73.	74.	77.3	88.50	72.60	73.	81.8	78.8	74.00	87.50	61.60	63.50	66.	83.	70.5	94.
Firebox heat. surf. ÷ total H. S., %	3.63	6.46	4.13	4.45	3.92	4.42	3.90	5.05	4.38	7.12	7.80	4.23	6.25	6.80	5.18	4.25	5 98	6.6
Weight on drivers ÷ total heat. surf	61.00	76.90	55.2	66.50	59.5	61.90	62.20	63.9	49.	59.6	55.62	46.50	60.50	56.00	46.7	58.3	62.3	57.1
Weight total ÷ total heating surface	67.00	76.90	62.	74.50	59.5	65.10	62.20	73.8	60.	75.5	72.21	56.90	72.00	67.00	61.6	58.3	62.3	57.1
Total H.S. ÷ superheating heat. surf									6.3									
Cylinder volume, cubic feet	28.84	24.	20.75	20.75	19.	20.46	19.45	17.1	22.82	15.8	15.70	16.75	12.00	12.30	8.93	14.7	11.2	12.
Total heating surface ÷ cylinder vol	220.00	222.	275.	217.	295.	247.00	270.	229.	210.	218.	230.19	266.00	231.00	236.00	346.	314.	245.	260.
Superheating heating surf. ÷ cyl. vol									33.4									
Grate area ÷ cylinder volume	2.38	4.70	3.75	2.93	3 85	2.79	3.70	3.14	2.57	2.76	3.10	3.05	3.75	3.78	5.2	3.78	3.48	2.77
Reference in THE AMERICAN ENGINEER	1909 p. 181	1907 p. 341	1906 p. 371	1908 p. 477	1904 p. 237, 262	1909 p. 261	1909 p. 61	1907 p. 213	1907 p. 88	1906 p. 392	1909 Aug.	1909 p. 225	1907 p. 444	1908 p. 77	1905 p. 97	1905 p. 330	1904 p. 184	1906 p. 346

† Includes combustion chamber.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF THE PACIFIC (4-6-2) AND PRAIRIE (2-6-2) TYPES

TYPE	PACIFIC												PRAIRIE					
Name of road	P. R. R.	N. Y. C.	C. & A.	C & A.	N. P.	A. T. & S. F.	Erie	R. F. & P.	B. & O.	N. Y., N. H. & H.	C. B. & Q.	Mex. Nat.	A. T. & S. F.	L. S. & M. S.	C. B. & Q.	N. P.	G. N.	Wabash†
Road number or class.	K 28	3565	623	605	2,175	1290	2,511	84	P	I 1	S1	420	1800	4,724	R5	2,378	J1	G1
Builder	Amer.	Amer.	Amer.	Bald.	Amer.	Bald.	Amer.	Bald.	Amer.	Both		Bald.	Bald.	Amer.	Amer.	Amer.	Bald.	Both
When built	1907	1908	1909	1908	1906	1908	1905	1907	1906	1907	1906	1907	1906	1906	1906	1906	1906	1907
Simple or compound	Simple	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Comp.	Comp.	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	30,700	29,200	31,475	34,500	30,340	32,600	30,300	31,100	35,020	31,560	31,100	35,066	37,800	27,850	35,060	33,300	37,560	34,558
Weight, total, lbs	272,500	266,000	248,000	243,200	240,000	232,750	230,500	230,800	229,000	229,500	228,000	227,340	248,200	233,000	216,000	209,500	209,000	205,900
Weight on drivers, lbs	183,900	171,500	149,500	146,500	157,000	140,400	149,000	143,750	150,500	142,500	150,000	147,040	174,700	165,200	152,000	152,000	151,000	150,500
Weight on trucks, lbs				47,600	53,000	54,950	41,000	46,850	40,500	46,500	42,000		31,300	26,000	25,600		21,000	21,900
Weight on trailer, lbs				49,100	30,000	37,400	40,500	40,200	38,500	41,000	36,000		42,200	41,800	38,400		37,000	
Weight, tender loaded, lbs	143,800	164,000	165,120	161,800	141,350	165,200	163,000	350,000	147,000	134,000	148,200	142,660	175,000	159,900	148,200	139,500	151,000	153,000
Wheel base, driving	13′ 10″	14′	13′ 9″	13′ 9″	12′ 0″	12′ 8″	13′ 0″	12′ 10″	13′ 2″	13′ 1″	12′ 10″	12′ 0″	13′ 8″	14′ 0″	13′ 4½″	11′ 0″	13′ 0″	13′ 4½″
Wheel base, engine	35′ 2½″	36′ 6″	34′ 8½″	32′ 8″	33′ 5″	34′ 4¾″	33′ 8″	32′ 8″	34′ 3½″	33′ 5½″	32′ 9″	33′ 11″	33′ 9″	34′ 3″	30′ 8½″	28′ 11″	30′ 9″	30′ 8½″
Wheel base, engine and tender	67′ 3½″	67′ 11″	66′ 4″	65′ 8½″	62′ 10″	65′ 2″	65′ 1″	61′ 11½″	66′ 3½″	61′ 2″	64′ 3¾″	62′ 11″	65′ 0″	62′ 5½″	62′ 2¾″	57′ 3½″	63′ 8″	61′ 4¾″
Diameter of drivers	80″	79″	80″	73″	69″	73″	74″	73″	74″	73″	74″	67″	69″	79″	69″	63″	69″	70″
Cylinders, number	2	2	2	2	4	2	2	2	2	2	2	4	4	2	2	2	2	2
Cylinders, diameter	24″	22″	23″	23″	16½″ & 27½″	25″	22½″	22″	22″	22″	22″	17″ & 28″	17½″ & 29″	21½″	22″	21″	22″	22″
Cylinders, stroke	26″	28″	28″	28″	26″	28″	26″	28″	28″	28″	28″	28″	28″	28″	28″	28″	30″	28″
Valve gear, type	Wals.	Wals.	Pilloid	Wals.	Wals.		Steph.		Steph.		Steph.	Steph.	Wals.	Wals.	Steph.	Steph.	Wals.	Steph.
Steam pressure, lbs	205	200	200	200	220	160	200	200	225	200	200	220	225	200	210	200	210	210
Boiler, type	Str.	Conical	E. W. T.	W. T.	E. W. T.	Str.	Str.	Str.	Str.	Str.	W. T.	W. T.	E. W. T.	E. W. T.	W. T.	E. W. T.	Belp.	E. W. T.
Boiler, smallest diameter	78″	72″	72″	72″	72¾″	72″	74⅝″	74″	72″	70″	70″	70″	76″	70″	70″	72½″	72″	70″
Boiler, height center	119″			113″	115″	114¼″	113½″	112½″	112″	110″	109¾″	109″	115″	114″	107⅜″	115″	108″	107⅞″
Heating surface, tubes, sq. ft	4243	3981.6	3869.	3721.	2667.	3202	3131.	3917.	3,234.6	3743.	3,732.	3,527.	3,803.	3,678.	3,375.	2,105.	3,277.	3370
Heating surface, firebox, sq. ft	205	228.3	202.	206.	241.8	190	195.	190.	179.4	204.4	200.	186.	217.	227.	200.	235.	210.	190
Heating surface, total, sq. ft	4448	4209.9	4071.	3927.	2908.8	3392	3326.	4107.	3,414.	3947.4	3,932.	3,713.	4020.	3,905.	3,575.	2,340.	3,487.	3560
Heating surface, superheater, sq. ft							763.											
Grate area, sq. ft	61.86	56.5	49.5	33.	43.5	49.5	56.5	49′ 5″	56.24	53.5	54.	52.1	53.8	55.	54.	43.5	53.15	54.25
Firebox, length	111″	108⅛″	108″	120⅛″	96″	107⅞″	108⅛″	108″	108⅛″	108⅛″	108⅛″	113½″	107 1/16″	108⅛″	108⅛″	96″	116″	108⅛″
Firebox, width	80¼″	75¼″	66″	40¾″	65¾″	66″	75¼″	66″	75¼″	71¼″	72¼″	66¾″	71¾″	73¼″	72¼″	65¼″	66″	72¼″
Fuel, kind	Bit. Coal	Bit. Coal	Bit. coal	Bit. coal	Bit. Coal.	Oil	Bit. Coal	Bit. Coal	Bit. coal	Bit. Coal	Bit. coal.	Bit. coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	343	382	373	357	306	273	195	318	276	310	303	301	342	322	303	306	301	303
Tubes, number superheater							32											
Tubes, diameter, firetube	2¼″	2″	2″	2″	2″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2″	2¼″	2¼″
Tubes, diameter superheater							5″											
Tubes, length	21′	20′	20′	20′	16′ 9″	20′	20′ 0″	21′	20′ 0″	20′ 6″	21′ 0″	20′ 0″	18′ 10 1/16″	19′ 6″	19′ 0″	13′ 3″	18′ 6″	19′
Tender, coal capacity, tons	11	14	14	12½	12	33,009	16	12	15	14	13	12	14	15	13	12	13	15
Tender, water capacity, gals	7000	8000	8500	8,250	7,000	8,500	8,500	6,000	7,000	6,000	8,000	7,500	9,000	8,000	8,000	7,000	8,000	7,700
Weight on drivers ÷ tractive effort	6.00	5.84	4.74	4.26	5.2	4.33	4.95	4.62	4 3	4.5	4.8	4.2	4.6	4.4	4.3	4.6	4.	4.35
Weight, total ÷ tractive effort	8.85	9.11	7.90	7.05	7.9	7.12	7.7	7.65	6.6	7.25	7.3	6.5	6.6	8.3	6.2	6.3	5.6	5.95
T. E. × diameter drivers ÷ total H S	550.00	550.00	618.00	640.00	720.	700.00	669.	560.00	760.	585.00	585.	632.	650.00	565.	677.	900.	746.	680.00
Total heating surface ÷ grate area	72.00	74.50	82.30	119.	67.	68.50	58.7	82.90	60.5	73.50	71.3	71.2	74.	71.	64.8	53.8	65.	65.70
Firebox heat. surf. ÷ total H.S. %	4.62	5.35	4.98	5.24	8.3	5.60	5.85	4.64	5.23	5.20	4.85	5.	5.4	5.8	5.34	10.1	6.0	5.32
Weight on drivers ÷ total heat. surf	41.50	40.70	36.60	37.30	53.8	41.50	45.	34.90	44.	36.20	38.	37.4	43.5	42.	42.5	65.	43.5	42.20
Weight total ÷ total heating surface	61.20	63.10	61.00	62.00	82.5	68.50	69.5	56.10	66.5	58.20	58.	61.1	62.	61.	60.7	89.5	60.	58.00
Total H.S. ÷ superheating heat. surf							4.35											
Cylinder volume, cubic feet	13.60	12.32	13.50	13.00	9.9*	16.00	12.	12.30	12.3	12.30	12.3	11.6*	12.1*	11.7	12.3	11.2	13.2	12.32
Total heating surface ÷ cyl. volume	326.00	341.00	302.00	290.00	294.	212.00	277.	334.00	278.	321.00	318.	330.	334.	335.	290.	209.	265.	290.00
Superheating heating surf. ÷ cyl. vol							63.5											
Grate area ÷ cylinder volume	4.55	4.58	3.67	2.44	4.3	3.10	4.7	4.03	4.56	4.20	4.39	4.54	4.43	4.68	4.46	3.89	4.03	4.41
Reference in THE AMERICAN ENGINEER	1907 p. 267	1908 p. 164	This Issue	1908 p. 399	1906 p. 411	1908 p. 112	1905 p. 172	1907 p. 407	1906 p. 257	1907 p. 431	1906 p. 300	1907 p. 70	1906 p. 435	1906 p. 204	1906 p. 300	1906 p. 392	1906 p.365	1908 p. 31

* Equivalent simple cylinders. † Designed for fast freight service.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF TYPES OTHER THAN THE PACIFIC AND PRAIRIE

TYPE	ATLANTIC. (4-4-2.)									TEN WHEEL. (4-6-0.)						AMERICAN (4-4-0.)		
Name of road	U. P.	Erie	C. M. & St. P.	P. R. R.	N. Y. N. H. & H.	N. P.	C. B. & Q.	Har. Lines	C. R. I. & P.	n. & A.	S. P.	D. L. & W.	N. Y. C.	N. C. & St. L.	C. & N. W	C. R. R. of N. J.	D. L. & W.	L. S. & M. S.
Road number or class	21	537	951	2,760	F1	603	P3	A-81	1,019	1,916	2,317	1,012	2,099	284		852	955	Pony
Builder	Baldwin	Amer.	Bald.	Amer.	Amer.	Bald.	Bald.	Bald.	Amer.	Amer.	Bald.	Amer.	Amer.	Bald.	Amer.	Amer.	Amer.	L. S & M.S.
When built	1906	1905	1907	1905	1907	1909	1904	1905	1905	1908	1907	1905	1905	1908	1907	1905	1905	1906
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Bal.comp	Simple	Simple	Simple	Simple
Tractive effort, lbs	24,281	23,860	22,200	23,300	24,670	24,760	21,400	23,560	24,700	31,000	36,570	35,100	31,000	29,200	30,900	23,120	23,710	15,700
Weight, total, lbs	209,000	206,000	204,119	200,500	200,000	197,050	196,600	196,000	191,300	208,000	203,300	201,000	194,500	181,400	179,500	161,300	151,200	126,600
Weight on drivers, lbs	110,000	115,000	105,966	117,200	105,500	100,800	101,200	105,000	107,100	158,000	160,000	154,000	148,000	134,000	135,500	111,300	100,000	85,100
Weight on trucks, lbs	53,000	52,000	52,353	52,500	48,000	51,950	54,200	45,000	42,400			47,000	46,500	47,400	44,000	50,000	51,200	41,500
Weight on trailer, lbs	46,000	39,000	45,800	30,000	46,500	44,300	41,200	46,000	40,800	155,800	43,300							
Weight, tender loaded, lbs	162,200	162,800	130,000	132,500	134,000	122,950	120,400	162,200	144,000		141,366	120,000	143,500	118,000	139,500	122,200	110,000	105,200
Wheel base, driving	7′ 0″	7′ 0″	7′ 6″	7′ 5″	7′ 3″	6′ 10″	7′ 3″	7′ 0″	7′ 0″	15′ 10″	13′ 10″	14′ 4″	15′ 10″	12′ 0″	14′ 10″	8′ 3″	8′ 6″	9′ 0″
Wheel base, engine	27′ 10″	24′ 0″	32′ 2″	31′ 11″	28′ 2″	27′ 10″	30′ 2″	27′ 7″	27′ 5½″	26′ 10½″	25′ 10″	25′ 6″	26′ 10½″	26′ 0″	25′ 10″	23′ 1½″	24′ 5″	25′ 1¼″
Wheel base, engine and tender	58′ 5″	60′ 9″	66′ 9″	61′ 4″	56′ 1″	57′ 3″	57′ 6¾″	58′ 2″	57′ 2″	59′ 3″	58′ 1¼″	54′ ¼″	59′ 2″	55′ 2″	57′ 9″	49′ 2″	51′ 3½″	48′ 4¾″
Diameter of drivers	81″	78″	85″	80″	79″	73″	78″	81″	73″	69″	63″	69″	69″	66″	63″	69″	69″	63″
Cylinders, number	4	4	4	4	2	2	4	2	2	2	2	2	2	4	2	2	2	4
Cylinders, diameter	16″ & 27″	15½ & 26″	15″ & 25″	16″ & 27′	21″	21″	15″ & 25″	20″	21″	22″	22″	21½″	22″	16″ & 27″	21″	19″	20″	12½″
Cylinders, stroke	28″	26″	28″	26″	26″	26″	26″	28″	26″	26″	28″	26″	26″	26″	26″	26″	26″	20″
Valve gear, type	Wals.	Steph.		Steph.		Wals.	Steph.	Steph.	Steph.			Steph.	Steph.	Wals.	Wals.	Steph.	Steph.	Wals.
Steam pressure, lbs	200	220	220	205	200	185	210	200	185	200	200	215	200	210	200	200	185	180
Boiler, type	Str.	E. W. T.	W. T.	Belp.	E. W. T.	Str.	E. W. T.	Str.	Str.	E. W. T.	W. T.	Str.	W. T.	W. T.	E. W. T.	W. T.	Str.	W. T.
Boiler, smallest diameter	70″	70¾″	66″	65⅝″	68″	72⅛″	64″	70″	72″	72⅛″	72″	74⅝″	70⅝″	64″	66¾″	62¼″	61⅜″	50″
Boiler, height center	113″	111⅜″	114″	109″	110″		108⅛″	113″	108″	115″	102″	116½″	115″	107″		113″		78″
Heating surface, tubes, sq. ft	2475.	3453.6	3008.	2680.2	3041.	2112.	3050.5	2475.	2227.6	3104.5	2788.	3156.3	3124.7	2550	2808.4	1838.1	1947.9	1,326.
Heating surface, firebox, sq. ft	180.	181.1	168.	181.4	204.4	173.	155.5	174.	161.8	203.3	206.	221.7	202.7	185	150.8	167.6	190.8	140.
Heating surface, total, sq. ft	2655.	3634.7	3194.	2861.6	3245.4	2285.	3206.	2649.	2389.4	3307.8	2994.	3378.	3326.7	2735	2959.2	2005.7	2138.7	1,466.
Heating surface, superheater, sq. ft						480.			338.									
Grate area, sq. ft	49.5	56.5	45.	55.5	53.5	43.5	44.1	49.5	44.8	54.9	32.1	94.8	54.93	34.8	46.27	81.6	87.54	21.
Firebox, length	108″	108⅛″	107″	111″	108⅛″	96″	96⅛″	108″	96″	105⅛″	124″	126⅛″	108⅛″	120″	102⅛″	122⅛″	126⅜″	96″
Firebox, width	66″	75¼″	60⅛″	72″	71¼″	65¼″	66¼″	66″	67¼″	75¼″	37¼″	108¼″	75¼″	41⅜″	65¼″	96¼″	100″	31″
Fuel, kind	Bit. coal	Bit. coal.	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Anth. coal	Bit. coal	Bit. coal	Bit. coal	Anth. coal	Anth. coal	Bit. coal
Tubes, number firetube	297	388	268	315	347	156	264	297	173	400	355	398	400	256	337	280	280	187
Tubes, number superheater						22			54									
Tubes, diameter, firetube	2″	2″	2¼″	2″	2″	2″	2¼″	2″	2″	2″	2″	2″	2″	2¼″	2″	2″	2″	2″
Tubes, diameter, superheater						5½″			3½″									
Tubes, length	16′ 0″	17′ 0″	19′	16′ 3″	16′ 10″	16′	19′ 0″	16′ 0″	16′ 0″	14′ 11″	15″	15′ 3″	14′ 11″	17′	16′ 0″	12′ 6″	13′ 4¼″	13′ 6½″
Tender, coal capacity, tons	10	16	10	12½	14	9	12	10	12	12	2,940	10	12	10.5	10	12	10	10
Tender, water capacity, gals	9,000	8,500	7,000	5,500	6,000	6,000	6,000	9,000	7,000	8,000	7,000	6,000	7,000	5,500	7,500	5,000	5,000	4,300
Weight on drivers ÷ tractive effort	4.53	4.82	4.75	5.	4.27	4.05	4.7	4.48	4.2	5.10	4.37	4.38	4.77	4.58	4.38	4.8	4.22	5.4
Weight total ÷ tractive effort	8.6	8.63	9.20	8.6	8.10	7.95	9.2	8.35	7.8	6.70	5.57	5.72	6.27	6.27	5.80	6.95	6.4	8.1
T. E. × diam. drivers ÷ total H. S.	740.	513.	610.	650.	600.	790.	518.8	717.	754.	647.	770.	717.	647.	705.	655.	800.	765.	670.
Total heat. surf. ÷ grate area	53.8	64.3	70.50	51.6	60.50	52.30	73.	53.6	53.3	60.20	93.	35.6	60.5	78.50	64.	24.7	24.4	69.5
Firebox heat. surf. ÷ total H. S. %	6.8	5.	5.30	9.37	6.30	7.60	4.85	6.6	6.75	6.15	6.90	6.6	6.1	6.80	5.10	8.4	8.9	9.5
Wgt. on drivers ÷ total heat. surf	41.5	31.7	33.10	41.	32.60	43 80	31.5	39.6	44.8	51.	53.40	45.6	44.5	49.00	45.75	55.3	46.8	58.
Wgt. total ÷ total heat. surf	78.9	56.8	64.	70.	61.80	79.50	61.3	74.	80.	67.	68.	59.8	58.7	67.00	60.50	80.5	71.	86.5
Total H. S. ÷ superheating heat. surf						4.76			7.08									
Cylinder volume, cu. ft	10.2†	8.93†	9.†	10.2†	10.40	10.40	8.3†	10.2	10.4	11.40	12.30	10.9	11.4	10.20	10.4	8.6	9.5	5.7
Total heat. surf. ÷ cyl. vol	262.	408.	355.	280.	311.	219.00	387.	260.7	230.	288.	243.	311.	292.	268.00	287.	233.	224.	257.
Sup. heat. surf. ÷ cyl. vol						46.20			32.5									
Grate area ÷ cyl. vol	4.83	6.27	5.	5.42	5.16	4.19	5.3	4.85	4.3	4.8	2.61	8.68	4.8	3.40	4.45	9.5	9.2	3.68
Reference in THE AMERICAN ENGINEER	1906 p. 308	1905 p. 287	1908 p. 37	1906 p. 73	1907 p. 471	1909 p.195	1904 p. 212	1905 p. 154	1905 p. 329		1907 p. 481	1905 p. 407	1905 p. 59	1909 p. 52	1907 p. 247			1906 p. 293

† Equivalent simple cylinders.